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Next Issue On Sale November 13, 2018

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Alan Dexter

IT ISN'T ABOUT EARLY ADOPTERS ANYMORE...

I WAS TEMPTED to dedicate this intro to thanking early adopters. The guys and gals who have helped shape today's tech industry. The reason is because it feels like we need these early adopters to step up to the plate again in order to make Nvidia's real-time ray-traced dreams a reality. And given the price tags hanging from its new GPUs, Nvidia certainly needs to woo anyone who values potential over any current performance metric.

The more I thought about it, though, the more I realized that the days of one or two (thousand) early adopters helping to define the market are behind us. Even at these new, far more eye-watering prices, it's not enough to sell a few cards. The whole PC market has to adopt a new way of working, and that's not easy.

The problem is scale. Early adopters don't have the impact they once did, because the markets involved are huge. When the PC was in its infancy, a few key players could really change what was possible. New ideas could be adopted relatively quickly, and the industry would march to whatever new beat was flavor of the month. It helped that there were often real problems that needed sorting, but that's another topic for another day.

However, as we've seen with the likes of stereoscopic 3D, VR, and numerous other recent technologies, it isn't enough to get a few key people interested. The tech has to deliver. And there needs to be support from the industry, too. There has to be a compelling reason to drive that technology, for it to hit the mainstream, and to make people sit up and listen.

To throw some numbers at this, according to Newzoo, the global games market is worth around $138bn. The PC market accounts for $33bn of that, while consoles (essentially PCs as well) roll in at just under $35bn. Basically, half the market is defined by PC hardware (with the other half swallowed up by mobile gaming). At the same time, modern triple-A games can cost $50–60 million to produce, and take years to develop. Gaming is a behemoth that doesn't adapt very quickly to new ways of doing things.

Into this pricey landscape, something as radical as changing how games are rendered can't be undertaken lightly. The fact that Nvidia has 11 real-time ray-traced games in the works is impressive, especially as there are some seriously big hitters in that list *(Shadow of the Tomb Raider, Battlefield V,* and *Metro Exodus* are all expected to sell in big numbers). Even so, the difference a new technology makes must have a wow factor, and I'm not sure I've seen anything that compels me to buy an RTX card for gaming alone.

However, these cards do have an incredible amount of potential. And not just for gaming, because there's plenty they can do that a normal graphics card can't. Enough potential, in fact, to have me reaching for that pre-order button. And I wouldn't consider myself an early adopter. No, for me, it's all about the tech. And its potential. Here's to the future!

Alan Dexter is Maximum PC's *executive editor and a punisher of hardware. He's been a tech journalist for over 20 years, and has no problem upsetting the PC industry as a whole.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

Ray Tracing Goes Hardware

First of a new generation of Nvidia cards

THE LAUNCH of a major new range of graphics cards is always a notable event, but Nvidia's new GeForce RTX range is something beyond that. These are the first of a whole new generation of cards based on the Turing GPU. Nvidia's president, Jensen Huang, has claimed this is the company's most important GPU since the Tesla, in 2006. It shows where cards are heading over the next few years, and it's going to look sumptuous.

There are three new cards initially: The RTX 2080 Ti and RTX 2080 are due first (and we've got one—see page 76). The Ti version is an eye-watering $999; the plain version is a still-substantial $699. The RTX 2070 is due to follow in a month, at around $499. There are Founders Editions, too, for an extra $100–200. These are huge prices, even if they are the vanguard of a new generation.

The flagship RTX 2080 Ti has a "Big Turing" GPU, with 4,352 CUDA cores, 11GB of VRAM, and can manage 13.4Tflops, with a hefty 250W TDP. The 2080 has 8GB of memory and 2,944 CUDA cores. It churns out 10.1Tflops. The 2070 comes in at 7.5Tflops and is armed with 2,304 CUDA cores.

The fuss is encapsulated in the "RTX" part of the name. These cards have been built to hardware-accelerate ray tracing, a first for consumer cards. They employ Nvidia's ray-tracing API, RTX, launched in March. This is compatible with Microsoft's DirectX Raytracing, DXR. Full real-time ray tracing may be a goal, but it's a bit much to ask for just yet. RTX enables selective ray tracing, a hybrid system that enables specific parts or aspects of a rasterized scene to be mapped out the hard way. Great for creating realistic shadows and highlights. The Turing GPUs contain what Nvidia calls an RT core, dedicated to running specific ray-tracing calculations. It also boasts hardware AI, a machine-learning engine to predict the workflow.

As yet, we have no game developed from scratch to make use of ray tracing; it's all added sparkle. So far, there are 11 games with some aspects of ray-tracing support. This is still a crushingly complex process—turn on ray tracing in *Battlefield V,* and your frame rate can drop to 60fps at 1080p, and that's using the 2080 Ti.

> As yet, we have no game developed from scratch to make use of ray tracing.

Nvidia's RTX cards have real-time ray tracing built into their Turing GPUs.

Nvidia's previous GPU architecture, Pascal, isn't going anywhere just yet either. Only the top of the range gets Turing GPUs for now. For more mainstream markets, the 10-series GTX range will soldier on. It's widely thought that the lower 20-series cards won't support RTX either. Rather than deliver a sub-par experience, they will skip it altogether.

Where is AMD? Well, it also has a ray-tracing API, Radeon-Rays, but for now it seems to be content to sit this one out and let Nvidia take the high ground, while it concentrates on the bigger markets lower down the tree.

This is the biggest launch from Nvidia for years. It has pitched these first cards very high, which has already prompted some pushback, especially as there's so little to run the RTX hardware on at the moment. The first generation of any new architecture is often among the most expensive, but never the best. If you buy a 2080 Ti just for ray tracing, you'll be disappointed for now, with few games as yet, and those have limited support. What it does do is point the way, and the way leads to wonderful graphics. Yes, for now it's going to be painfully pricey, but the first step to bringing real-time ray tracing to your desktop has been made. **–CL**

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TOP MAC APP IS SPYWARE

Apple Store anti-malware app has been data harvesting for years

ADWARE DOCTOR, a top-ranked $5 app from the Apple Store, has been revealed as spyware. It has been sending users' private data to servers in China. Security researcher Patrick Wardle was tipped off by user forum posts, and after investigation posted his finding on Malwarebytes, then passed the results to Apple. Disappointingly, Apple took months to kick the offender from the Store.

To scan for malware, Adware Doctor requests universal access when first used, which circumvents much of the internal security between apps. It then raids your browser history, collects a list of software you've downloaded, your iTunes history, and a list of running processes. The data is collated into a password-protected zip folder, and sent to a third-party. To keep users happy, and oblivious, it also does the job it claims to, removing other malware.

Adware Doctor was originally called Adware Medic, mimicking an existing app called AdwareMedic. It was removed, but resurfaced under a new name, and became the top paid utility. Helping push it to the top of the rankings were over 6,000 five-star reviews. These now look highly suspicious. The server receiving the stolen data is now inactive, and the app's developers are not taking calls. Adware Doctor is not alone; Dr. Unarchiver and Dr. Cleaner also collect and pass on browser histories and more.

Apple's tightly-controlled environment has traditionally been seen as a secure platform, so Adware Doctor's unmasking is hugely embarrassing. This was a seemingly legitimate app, presented front and center on Apple's showcase marketplace, which Apple says is "the safest place to download apps for your Mac." Malware often relies on lax procedures and assumptions in order to get installed. Apparently, being a top-rated utility on the Apple Store doesn't mean we can assume anything is safe. Ouch. **–CL**

THE END OF THE URL

GOOGLE WANTS TO CHANGE THE WEB ADDRESS

THE UNIFORM RESOURCE LOCATOR (URL) is messy, confusing, and can get long—making it difficult to remember, and easy to fake. Most people really don't want or need to know the full path of a webpage. Google has been musing on this for years, and is getting ready to unveil an alternative system, which will remove the clutter, and leave a more natural English URL. "We want to move toward a place where web identity is understandable by everyone," said Chrome's engineering manager, Adriene Porter Felt.

It's not really in the hands of Google, of course. However much it would like to, Google doesn't actually control the Internet, although it does have the world's most popular browser. It was instrumental behind the move to HTTPS encryption, for example. Whether such a fundamental change should, or can, be made at browser level is another matter, however good the idea. The security issues are paramount; get this wrong, and it'll explode. Exactly how Google will make the switch remains to be seen, but something's coming. **–CL**

ONE IN FOUR DUMP FACEBOOK

Although Facebook's numbers don't drop

ACCORDING TO NEW FINDINGS from the Pew Research Center, 26 percent of US Facebook users have uninstalled it in the last year; the figure rises to 44 percent for those aged 18–29. Over half claim to have adjusted their privacy settings, too. The poll was taken between May 29 and June 11, when concerns about data sharing peaked.

Startling stuff, although tellingly, the number of reported active accounts from Facebook didn't plunge over the same period; growth merely leveled off. Possibly, many of those dumping Facebook weren't active users in the first place, or went back again. The headline figures may be open to interpretation, but it does indicate that people are adjusting their relationship with the company—when so many report changing usage, you know something is afoot. Facebook lives and dies by the number of active accounts, and it's a relationship strongly based on trust. There's clearly still work to do here. **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

HEADS UP BIKERS
JDI has developed an experimental heads-up display fitted to a motorcycle helmet.

FOLDING PHONES
Samsung is set to launch its foldable-screen phones before the year's end; a tablet when you want it to be.

ULTIMATE GAMING CHAIR
Acer's new 495lb Predator Thronos chair has mounts for three 27-inch monitors, fancy lighting, it vibrates, and reclines.

TRAGEDIES

GLOFO DROPS 7NM
Huge costs push AMD partner GlobalFoundries out of market, leaving three major fabricators capable of making 7nm chips.

PRIUS FIRE RISK
Toyota has recalled one million cars built since 2016, due to a potential overheating problem.

TWITTER BANS INFOWARS
The infamous Alex Jones has had his Twitter account pulled; the company cites infringements of its abusive behavior policy.

AMD's New Cheap and Fast Processor

AMD has a new desktop CPU using its Zen core; this time it's aimed at the low-end market, and the old Athlon brand name has been resurrected. The Athlon 200GE is a dual-core, four-thread chip, with Radeon Vega 3 graphics (196 GPU cores). It runs at a flat 3.2GHz, and has a TDP of 35W. It's overclock locked—pity—and slots into AM4 motherboards. The best bit is that it's just $55 a pop. It takes the fight directly to Intel's Pentium Gold series, specifically the G5400. Faster versions are to follow, with the 220GE and 240GE. Initial benchmarks look encouraging, but there are no independent ones yet. The low TDP, fairly decent on-board graphics, and low, low price means we have a cracking new budget chip. Please unlock it, though. **–CL**

Huawei Cheats During Benchmarks

Huawei has been sending out phones with secret benchmark modes to inflate their GPU benchmarks. The phone detects the benchmark being run, and sets the SoC to operate at full throttle, going well past its thermal envelope. The cheat was uncovered by using identical private versions of benchmarking software, which hide their names and identifying details. During the legitimate test of a phone running a Kirin 970 SoC, it drew an average of 4.39W, but during the doctored test, it drew 8.57W. It also managed to nearly double its benchmark scores. At all other times, the phone operates as normal. Temperature is a problem for phones, where chips can overcome the limited cooling; most phones almost never run at full-tilt during normal use. **–CL**

Oculus, Sony, and HTC only made about 100,000 sales each last quarter.

Virtual Reality Sales Crash

VR HAS BEEN the next big thing for so many years that it is has almost become comical. Recent advances in hardware, and backing by some big names, have pushed it back into the spotlight; however, sales figures for the last quarter have emerged, and it's not good news. Sales are down 33.7 percent on the same time last year. The high-end tethered headsets contracted by 37.3 percent. Standalone headsets bucked the trend, but overall numbers are still very low; just 0.3 percent of Steam users can enjoy virtual worlds.

These are stark figures, but there are consolations. Previous sales figures were inflated by Samsung, Google, and Alcatel bundling cheap screenless VR viewers; this has declined from over a million to around 400,000. And potential growth is seen in the business and commercial sectors, but this is all theory so far.

The reasons behind VR's sluggish growth are manifold: People find it hard to try VR; there's a lack of content; and a bewildering variety of formats, from the cheap world of, essentially, strapping a phone to your head, all the way up to expensive custom systems.

Some pundits have labeled high-end PC-based gaming VR as dead. Harsh stuff. It's clearly not healthy, though. We've still to see proper VR games being developed, written ground-up to deliver a VR-focused experience. So far we have one: *Resident Evil 7*. Hardware 3D cards were equally pricey at launch, but quickly gained a plethora of titles.

There is something vital missing for VR, and that's enough vocal, and financially enthusiastic, people clamoring for it. Microsoft's move to drop the Xbox One VR headset looks like a reasonable business decision. VR is still not the next big thing. **–CL**

WIN 7 EARNS A REPRIEVE

But only for business users, and it will cost

WINDOWS XP was a very popular operating system, and that eventually became something of a problem for Microsoft, because people wanted to carry on using it. Eventually, Microsoft had to offer Extended Support, and even built a special XP Mode into subsequent versions of its OS. It looks as though Windows 7 is going the same way. It's still hugely popular, despite nearing the edge of Microsoft's aggressive upgrade policy. Opinion is divided on exactly how popular it is: StatCounter has Win 7 and Win 10 on roughly equal terms, while Net Applications still puts Win 7 eight points ahead. Whichever metric you use, it's still on a lot of machines worldwide, and the upgrade rate is sluggish.

What Microsoft calls Mainstream Support for Windows 7 ended back on January 14, 2015. The Extended Support it has been enjoying since then keeps security updates going, and a few other bits and bobs, but ends any major revisions, new features, or support (although you can pay for this). Windows 7 users can currently expect to stop getting these updates on January 14, 2020. For business users, with a lot of systems to upgrade, that's not very far away. However, Microsoft has relented, to some extent, and is to offer an Extended Security Updates program, which will keep the all-important security patches going for up to three years. It'll cost, though, and is only available for business users.

What about the rest of us? Well, Microsoft was obliged to keep Windows XP security patches going until 2014, so there is always hope. Pulling all security updates on an operating system that's still used by hundreds of millions of machines worldwide would take a huge amount of hubris. Over to you, Microsoft.... **–CL**

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Jarred Walton

TECH TALK

Nividia's Turing Radically Alters the GPU World

IF IT FEELS as though graphics technology has been somewhat stagnant for the past several years, prepare for some turbulent times. Nvidia's new Turing architecture blows the doors wide open for what we can expect from future games.

Earlier this year, Nvidia demonstrated "real-time" ray tracing on a DGX Station, a $69,000 piece of hardware, with four Tesla V100 GPUs. Six months later, Nvidia brings that level of performance to a single $1,200 graphics card, thanks to Turing.

There are so many changes with Turing, that it's difficult to say which will be the most important. The traditional GPU core now has a dual-issue superscalar architecture, similar to that of CPUs, and can concurrently execute integer and floating-point operations, as well as Tensor and RT instructions. Nvidia says the new schedular and pipelines make Turing's CUDA cores 35 percent more efficient than Pascal, and with more cores, the gap is even larger. GDDR6 memory support likewise boosts bandwidth by 30–40 percent, and enhancements to memory compression technologies and the L2 and L1 cache enable an additional 20 percent increase in effective bandwidth.

That should benefit existing games, but the real changes are in the Tensor cores and RT cores. Tensor cores were first introduced to Nvidia GPUs with the Volta architecture, and Turing adds support for INT8 and INT4 data types, at 2x and 4x the FP16 performance. Not all algorithms can benefit from the reduced precision, but deep-learning workloads that can tolerate quantization (i.e. mapping a continuous range of values to a limited discrete set of values) should see significant improvements in performance.

> A single Turing GPU can outperform a DGX Station for real-time ray tracing.

But why would our graphics cards even need deep-learning capabilities? It's not just about supercomputers and AI; deep learning can be applied to a variety of graphics workloads. Nvidia has created DLSS (Deep Learning Super Sampling) as one such solution, with two methods of operation. Vanilla DLSS upscales 1080p content to 4K using a trained network to deliver similar quality to 4K, plus TAA at significantly higher frame rates. DLSS 2X skips the upscaling and focuses on antialiasing, which uses a network trained with 64x super-sampling images to achieve better AA results than TAA and MSAA.

The Tensor cores are also necessary for the denoising algorithms used with ray tracing, which I'll hit in a minute. For FP16 inference workloads, such as DLSS and denoising, the Turing TU102 in the RTX 2080 Ti is over 10 times faster than a single GTX 1080 Ti. The prospects for deep learning are unbounded, and it's one of the fastest growing areas of research in the computer world. We might even see improved AI in games, thanks to the Tensor cores. And if you're worried about proprietary Nvidia tech, Microsoft's DirectML API aims to do for deep learning what DirectX did for graphics, so other vendors' solutions aren't locked out.

Turing also includes new RT cores for ray tracing, which accelerate the computations involved with the BVH (Bounding Volume Hierarchy) algorithm, a popular optimized tree-based acceleration structure. There are two parts to the RT cores. First, the tree traversal, and second the ray/triangle intersection tests. Nvidia says using compute shaders to perform the BVH operations requires thousands of instructions per ray, which would tie up the CUDA cores. The RT cores are an order of magnitude faster, which is why one Turing GPU can outperform a DGX Station for real-time ray tracing.

Multiple games are already working to include ray tracing, using a hybrid rendering approach, where rasterization is used for drawing object geometry and textures, and ray tracing focuses on generating accurate shadows and lighting, reflections, and refractions. The quality of ray tracing can be scaled, so lower-tier GPUs could still hit acceptable frame rates, while faster GPUs can cast additional rays to improve rendering quality.

It's a brave new world for real-time computer graphics, and Nvidia's Turing architecture is the first-gen standard bearer. It's not difficult to imagine future Nvidia GPUs doubling and quadrupling the number of RT cores, enabling even higher levels of ray tracing effects. I say bring it on.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

THE LIST

THE MOST EXCITING GAMES OF GAMESCOM 2018

LIFE IS STRANGE 2 New cast, same thoughtful teen drama with a supernatural bent, and ace soundtrack.

RAGE 2 All the bombast and mechanical perfection of the original, now featuring colors other than brown.

DYING LIGHT 2 Moral quandaries, parkour, and zombie-bashing; this goes well beyond the original's remit.

BATTLEFIELD V Ah, sweet WW2. How we missed you in our multiplayer shooters. Let's never fight again.

DEVIL MAY CRY 5 It's been a long time since any game let you combo this hard or with as much style.

ASSASSIN'S CREED ODYSSEY Conquer an archipelago, in a new era, with new combat mechanics.

HITMAN 2 Like playing dress-up? Bludgeoning strangers with didgeridoos? We've found your game.

CYBERPUNK 2077 CD Projekt Red's new IP is vast in scope, thematic meatiness, and weighty RPG systems.

Alex Campbell

OPEN SOURCE

Has Open Source Been a Failure? That Depends...

There's an argument that open source has failed, in an economics sense of the word, at least. While a market failure might have been inevitable, given open source's strange alliance of differing ideals, a market failure does not mean that open source as a system has failed.

If you use any type of digital electronics, there's a near certainty that the hardware employs open-source software on some level. Hell, my car has a menu item to show open-source licenses for some of the packages used in the vehicle. To say open source has failed is an audacious statement. Linux is the dominant server operating system, Android the dominant mobile OS, and even Microsoft releases open-source products (Visual Studio Code), and became landlord for open-source projects (GitHub).

But that's the argument made by John Mark on Medium. He says that because open source has enabled the Googles and Amazons of the world to prosper by standing on the shoulders of open-source projects, open source has failed as a social project. But first, let's look at open source as it exists.

Open-source and free software has been host to strange bedfellows. If you've read or heard Richard Stallman—the spiritual head of the Free Software Foundation—you'll notice that a lot of his ideas are centered around the idea of user freedom. The free software ideal is that there are programs written for and by the users. It sounds a lot like seizing the digital means of production. Some open-source advocates—especially in the cryptocurrency world—have a distinctively libertarian bent, rejecting central authorities and governments wherever possible. This is certainly an odd alliance, but it has a distinctive consequence: ensuring market failure.

From an economic view, Mark has a point. Open source is an example of how a market failure can exist without causing the economic havoc that the word "failure" implies. John Mark asserts that, "Developing open-source software is not a public good." I disagree, and the failure that he speaks of is analogous to other public goods.

In economics, a "public good" is both non-rivalrous and non-excludable. Non-rivalrous means that if someone uses the thing, it doesn't stop you from also using it; non-excludable means that once the thing is provided, you can't stop people using it. Open-source and free software is a public good almost by definition. The problem with public goods is free-ridership, or when people benefit from the good without paying for (or contributing to) it. This is also known as the tragedy of the commons.

Lighthouses are classic examples of public goods.

Unlike natural resources, there is no central authority in open source to compel investment in and maintenance of the system. Again, this is largely by design.

Mark also argues that open source has increased inequality by allowing corporations like Amazon to build fortunes using tools that are free to everyone, resulting in open source's failure as a means to deliver us from inequality. The same could be said of highways. That doesn't mean open source has failed us, any more than roads have failed society because UPS built a business on delivering packages using public infrastructure. I argue that open-source and free software has succeeded in allowing users to choose OSes and programs, and reject corporate offerings. The goal of free software was never about equality, but freedom. In this sense, it has been a resounding success.

Should companies invest in open source to give back to the system they derive so much value from? Probably. But many open-source contributions from companies are in projects that directly benefit their own businesses, with the community benefiting from the positive externalities of those contributions. Creating positive externalities isn't a bug or failure of open source, it's a central feature, even if it means Amazon realizes more benefit than John Q. Public.

Alex Campbell is a Linux geek who enjoys learning about computer security.

TALKING

BY **ZAK STOREY**

Gaming Chairs and You

Noblechair's Steven Levitt explains why investing in a good gaming chair is absolutely worth it

When it comes to PCs, we spend an inordinate amount of time covering all the details inside your rig. What we often forget is that your environment, from the desk to the lighting to the chair, is equally important for an enjoyable experience. Nowhere is this more true than where you place your backside. We sat down with Steven Levitt from Noblechairs to get to grips with gaming chairs, and find out why you might want to shell out on one.

Steven's been in the biz since 2008, working as a PR across the globe.

Maximum PC: So, Steven, you're business development manager at Noblechairs; can you tell us a little bit about your role and what it entails? What's your background? And what brought you to Noblechairs to begin with?

Steven Levitt: Hi guys. Sure thing—my day-to-day role consists of a ton of different responsibilities, from PR to marketing to working with content creators, exhibiting at events, and even dealing with the partnerships that surround our company. In short, my job is to make sure Noblechairs get everywhere. I started working in the gaming industry around 10 years ago, but I've always had an interest in gaming, especially in first-person shooters, which is where it all started. *Counter-Strike* was my game of choice way back when, but now I'm a massive fan of *PUBG*.

I started working at Overclockers UK, a small eseller, back in 2008. Starting out at the onsite retail shop, I quickly moved on up to a customer service position, then became a community manager, working on the forums and attending events, before finally becoming the PR manager in September 2015, mostly working with journalists across the country.

After doing that for around two years or so, I wanted to challenge myself, and to build up a brand—Noblechairs provided me with the perfect opportunity for that. As a brand, its premium aesthetic and design quality really connected with me.

MPC: Let's get to the nitty-gritty—what can you tell us about your brand? Give us some background on Noblechairs. Where did it originate? Where did the ideas come from? How did it all start?

SL: For Noblechairs, it all started back in 2016. The company was founded in Berlin, Germany, where the headquarters is situated today. We launched the Epic series that year—these were the very first addition to our range. Designed and inspired by some of the world's best racing cars, but built ergonomically and with premium materials, they were for those looking for something a little more bespoke than some of our competitors. We also now have the Icon and the Hero series, which both offer a different design style from that classic racing bucket seat, for those who find it a bit too "gamery." And then there's also the footrests and other accessories, too.

We really do strive to provide the very best seating experience, by working diligently with certified ergonomics, and incorporating impeccable quality and elegant design into all of our products. In short, no corners are cut, anywhere in the process.

MPC: Obviously, we have to ask about that big elephant in the room: These premium chairs do cost a lot of money, not only at Noblechairs, but generally across the board. What is it, do you think, that justifies their cost? Is it really worth putting down so much cash for a premium chair?

SL: If you compare any of our Noblechairs products with those of a cheaper alternative brand, you can almost immediately see the differences. Our chairs are in another league entirely, whether you're talking about the understated designs, the

thicker covering, the harder-wearing materials, or the stronger base—the cost is well worth it. Our mission is to ensure our range offers the very best quality, and provides you with a chair that will last for years to come, whilst also providing the support your back needs. As I've already said, I'm a gamer myself, and I know how much time I spend sitting down, and we honestly believe that everyone should have a good solid chair that can support your back properly, which is where Noblechairs comes in.

MPC: Let's talk design—can you give us a little bit of insight into the design process at all? How does Noblechairs go about developing these chairs for the market? What ergonomic considerations do you take into account?

SL: All of the design process is handled by the German office—they are the absolute experts when it comes to engineering and the iconic look of Noblechairs. They truly know how to create a stunning design, with the signature diamond stitching, all whilst maintaining that quality we pride ourselves on. In terms of ergonomic considerations, we are one of the only gaming chair brands around that possess both the widely recognized DIN EN 1335 certification (European standard for office chairs) and BIFMA accreditation (Business and Institutional Furniture Manufacturers Association of North America) for office chairs.

MPC: Given that the gaming chair market is so aggressively competitive, what do you think it is about Noblechairs in particular that makes your brand stand out from the rest of the crowd? What is it that gives you that competitive edge?

SL: Our brand stands out because we are all gamers ourselves. We understand what gamers and enthusiasts both want and expect. We saw that other chair brands were producing very gimmicky, almost childlike-looking chairs, whereas we want to be taken seriously, and come across as far more professional.

We also have a huge presence at almost all of the major events across the globe, including Insomnia, EGX, Gamescom, Computex, TwitchCon, E3, and a whole lot more. We are very active in the gaming chair market, and a big part of that is because we're so easily approachable, whether that's on or offline.

That said, although the chairs we produce do technically fall under the "gaming chairs" category, we also support a wide range of other customers, too, whether that's content creators, car enthusiasts, music artists, you name it.... Our chairs are even used in some blue chip companies across the world due to our aforementioned certifications.

MPC: More and more nowadays, we're seeing RGB LEDs make their way into everything from SSDs to mouse mats, headsets, and more, with the likes of Vertagear even showcasing an RGB gaming chair. Is this something we can expect from Noblechairs in the future? What are your thoughts on the RGB bandwagon?

SL: Personally, I don't mind RGB LEDs at all. After all, they do provide a good way to customize your peripherals, which are something you see, day in, day out, when you're sitting at your desk. In terms of putting RGB LEDs into a Noblechair, though? What would be the point of that? I'd rather we focus solely on the quality and comfort instead, as opposed to jumping on a gimmick that not only would you have to charge up, but you wouldn't even see most of the time.

MPC: As a brand, Noblechairs is very much at the top end of the market—is that trend likely to continue? Or is there possibly scope to expand in a more budget-friendly direction later down the line?

SL: It's true, Noblechairs is currently positioned more toward the higher end of the market when it comes to gaming chairs. However, that's not something that's likely to change, because we love to provide the very best. A more budget-friendly direction already exists in our sister brand, Nitro Concepts.

MPC: What would you say to someone who is curious about your chairs, but isn't quite sure whether they should bite the bullet and stump up the cash for one?

SL: As end users, we spend loads of money on the fastest PCs, monitors, and peripherals, yet folk often forget what they're sitting on. A huge percentage of PC users do not sit correctly, and this is partly because of the chair they are sitting on. I can honestly recommend spending that extra to get a Noblechair. In a few years, your back will be thanking you for it—trust me.

If you're still in doubt, hunt us out at one of the aforementioned events next time we're in the area, and you can try out our chairs in person before you buy. We like to let the chairs speak for themselves.

MPC: Before we finish, is there anything else you'd like to add?

SL: I'd like to thank absolutely everyone who has helped me along the way over the years—not only my friends at Noblechairs and Overclockers UK, but also all of the partners, streamers, journalists, and content creators who have helped get Noblechairs where it is today.

It's all about quality and ergonomics.

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Diagnostic Dilemma
> Authentication
> Future 4K Fun

Problems With Power?

Hi Doc, I have been having issues with my PC for the last year or so. It all started when the system stopped waking from sleep mode. I had to flip the PSU's power switch because the case's power and reset buttons were non-functional. Eventually, the problem evolved into the machine unexpectedly shutting down during normal use, though the fans kept spinning as if nothing was wrong. As before, I needed to flip the PSU's power switch off and back on to restart.

I suspected that my CPU was at fault, so played games that put a load on the host and graphics processors. However, those games ran fine, and I was unable to reproduce the symptoms. But if I browsed the Internet or jumped on YouTube, the machine shut down. The issue became so bad that shutdowns happened during startup, triggering Automatic Repair. Of course, Windows couldn't get through that before running into issues.

Now I think my PSU is the culprit. I unplugged the hard drives and the optical drive, and the machine won't boot up. So, as of this writing, I have a PC that won't start. The fans spin up and that's it. My specs include an Asus M5A97 LE R2.0, an AMD FX 6300 CPU at 3.5GHz, 16GB of RAM, an HIS Radeon HD 7350 graphics card, and an OCZ 500W power supply, all running Windows 10 Pro. Any ideas?

–Chris Gfrerer

THE DOCTOR RESPONDS: It sounds like your PC's bad behavior is eliminating troubleshooting steps that the Doc would recommend, all on its own, Chris. The fact that your motherboard won't even POST anymore with storage disconnected means the problem isn't related to Windows or a drive failure.

Now it's a matter of narrowing the focus to another hardware component. Try booting with a single memory module to eliminate faulty RAM as the cause. Otherwise, it may be necessary to find a spare PSU or motherboard. Damaged surface-mount components on either device could be causing the death spiral.

Solving USB Issues

Hello, Doc. In a recent issue, a reader wrote in about a problem with his Corsair K95 keyboard. He thought it was related to USB, as the keypad would not work after entering his PIN. That reminded me of an issue I had with my Corsair Strafe RGB—its keypad suddenly went "random."

What I discovered (after the usual frustration of checking drivers) was that I had downloaded a custom RGB profile with Corsair's iCue software, and that profile also changed the keypad layout. Once I changed it to another theme, the problem was solved. When Windows boots up to its login screen, iCue isn't loaded, so the keyboard works fine. But once the app fires up, everything goes haywire. I never realized that I did it to myself, so maybe Leland didn't either.

–Robert Provensal

THE DOCTOR RESPONDS: Thank you for the tip. After re-reading Leland's symptoms, it's plausible that he's suffering from something similar. If the Doc's suggestions didn't solve his issue, hopefully yours does.

Token Talk

Although I'm a fan of two-factor identification, I'm also concerned about SMS being the only option for the second factor. Even though cell phones are generally reliable, they do break and get misplaced, and cellular networks go down occasionally or are unavailable. At work, we use RSA tokens that work well and don't need an Internet connection. Do any email providers or banks use tokens or something other than a cell phone?

–Dennis Benker

THE DOCTOR RESPONDS: There are email services and financial institutions using hardware tokens for authentication (along with entertainment sites, payment services, gaming platforms, and cloud-based hosts). Check out www.twofactorauth.org for a comprehensive list of sites with two-factor authentication. The list includes whether that authentication is done via SMS, a phone call, email, hardware token, or software token.

Online Backups

I used to use Carbonite for online backup. Recently, the company implemented a new policy where it will only protect one hard disk per PC. I have four drives (one SSD for the OS, and three storage drives totaling 15TB). The cost of moving to Carbonite's business plan was prohibitive, so I canceled the service.

Are there any other options that would help me with

↘ submit your questions to: doctor@maximumpc.com

real-time offsite backup of my configuration (which I expect is the same multi-drive setup as 99 percent of readers)?

I currently back up to a home server, a secondary PC in the same house, and take external hard drives to a safe deposit box twice per year. I also have a Verizon Fios Gigabit service at home.

–Cory Notrica

THE DOCTOR RESPONDS: Who says you can't teach an old dog new tricks? Although the Doc is infamously reluctant to rely on cloud-based services, multiple conversations with *Maximum PC* readers and increased wariness of his decade-old NAS appliance have him shopping around for online backup options. Backblaze is the service he's leaning toward currently. Notably, it protects internal and external storage devices, there are no file size restrictions or data limits, you get multiple restore options, and a $5/month price tag seems exceedingly reasonable.

As for its limitations, Backblaze doesn't do bare-metal restoration, so you can't re-image Windows after a catastrophic failure. That's fine; the Doc has copies of his operating environment saved locally, and doesn't need online storage for that. Also, Backblaze isn't a file synching service. Again, no problem. The Doc uses his free OneDrive storage when he needs access to documents on multiple devices, or when he wants to share them with colleagues.

Time For an Upgrade

Hi again, Doc. You have bailed me out several times before, and I'm back for sage advice. I have two issues. I read your rescue media article, and have a question: I own multiple PCs, including one I use as a server with lots of storage. My main system is used half of the time for gaming, and the rest of the time for Adobe apps, Office, email, and web browsing. I clone the hard drives twice per year, and keep the images backed up to an external USB drive offsite. Should I care about all of that media rescue stuff, though? If I take a hit, I can throw a new drive in there and perform a full restore, right? What are your thoughts?

Secondly, my main PC is based on a Core i7-3770K, GeForce GTX 1060, and a SATA SSD for booting up. It's starting to show its age big time. When I play my AAA games with the graphics goodies maxed out, they're starting to stutter. The performance is still very playable, but I think it's time for an upgrade. I have a second Corsair 600T White that I bought when I built my current system, along with a Corsair 1050W PSU, so I'm well on my way. I'll probably buy a decent motherboard for an Intel Core i7-8700K, an NVMe SSD for Windows, a couple of hard drives for data that doesn't need to go on solid-state storage, and a 1TB SSD for my Steam library.

My biggest question marks are the graphics card and monitor. I've been using a 27-inch Dell at 1920x1080 for eight or nine years, but want to upgrade to either 1440p or 4K with a killer GPU. I could wait another year or more if it meant making the jump to 4K. It's important that I step up to a higher resolution, though.

–Jim Lawrence

THE DOCTOR RESPONDS: It sounds like the foundation of your next build is solid, particularly for an all-around PC biased toward gaming. If you don't plan to buy a new monitor for another eight or nine years, consider stretching your budget for the best screen possible. There are plenty of great-looking options in the 2560x1440 segment. But you clearly have your eye on 4K. In that case, Acer's Predator X27 and Asus's ROG Swift PG27UQ are the hottest models available. They both have native resolutions of 3840x2160, employ 27-inch IPS panels with overclocked refresh rates of 144 Hz, and support Nvidia's G-Sync HDR technology.

Driving playable frame rates at 3840x2160 is another matter. Nvidia's Pascal-based GeForce GTX 1080 Ti doesn't quite get there on a consistent basis. And as of this writing, we still don't know how the recently announced GeForce RTX 2080 Ti will perform. If you have the cash to spend on a $1,200 Founders Edition card, though, on top of $2,000 for one of those 4K monitors, the 2080 Ti will undoubtedly be your best bet for smooth performance in the latest games at such a demanding resolution.

With regard to your first question: It depends. Do you have a highly customized Windows configuration that would be tricky to set back up in the event of a hardware failure or unrecoverable software corruption? Or, are you diligent about keeping data protected, but don't have any reason to worry about the operating environment itself? At a certain point, the Doc stopped cloning his drive (it's an old installation of Windows, and could probably use a reformat anyway), and focused on making sure his important files were safe.

4K Video Playback

Hi Doc. My goal is to one day have a seamless 4K entertainment center, but I've been waiting for more content to become available, and maybe the ability to archive UHD Blu-ray discs that I own.

I have two questions. First, are there any AMD processors that can play back Netflix or other streaming services in 4K? My understanding is that Intel's seventh-gen Core processors and higher are the only ones with support for HDCP 2.2, along with maybe Nvidia's Pascal architecture. Second, can any AMD products play UHD Blu-ray discs yet? Again, it sounds as though Intel has this locked up with AACS 2.0. Anything expected in the future? **–Ben Hayashi**

THE DOCTOR RESPONDS: Streaming Netflix content at 4K is supported on newer Intel, Nvidia, and AMD graphics products now, so long as you're using Microsoft's Edge browser (under Windows 10, of course), an HDCP 2.2-compatible connection between your graphics card and display, and updated drivers.

Unfortunately, the latest build of CyberLink's PowerDVD 18 only supports Ultra HD Blu-ray playback on seventh-gen Core CPUs with Software Guard Extensions support, on-die HD Graphics 630/Iris Graphics 640, and a compatible mobo.

Nvidia's new GeForce RTX 2080 promises to push performance higher than ever—at a premium price.

THE WINDOWS 10 DIY SUPPORT MANUAL

If you've got a problem and nobody else can solve it, try looking a little closer to home

BY IAN EVENDEN

WHEN IT COMES TO TECH, a little knowledge goes a long way. Windows 10, especially as it becomes more mature, is growing in stability, and it's a long way ahead of its predecessors, but—and it's a big but—it is still beset by little niggles and gripes that can make it difficult to use. However, you're the master of your own domain, and you can be the master of your own PC. Those problems can be banished by a little knowledge, either of the right thing to do or the right place to look.

So, we're bringing you a collection of the most common Windows 10 problems and the best ways to solve them. We've broken them up into categories to help you find your way around, so the next time you run into an issue, check this guide—chances are the solution will be here, but if you're still stumped, we'll lead you to the right places to find the answer.

Struggling to understand how Windows Update works? Frustrated because it's not working the way it should? Then you've come to the right place. In this feature, we're also going to take you on a complete tour of Windows Update in Windows 7, 8.1, and 10. We take a close look at what Windows Update does and—critically—how it works. You'll discover the different types of update it provides, and how it packages them up and delivers them to your PC. If you're running Windows 10, you may be in for a shock, because we reveal how to take back control of how updates are delivered from Microsoft.

Speaking of taking back control, we'll also reveal how to manually stop Windows Update from forcing updates down your throat if you're running Windows 10 Home Edition, and take an in-depth look at how to update and control the process if you're running Windows 10 Pro, or an earlier version of Windows.

Last, but by no means least, we'll take a look at troubleshooting those pesky Windows Update problems you're almost certain to run into. You'll find out how to fix most problems using a combination of Windows and third-party tools, track down solutions to stubborn updates refusing to install, and even take steps to get your PC working again should an update render your PC unbootable. Enough talk, let's start taking control....

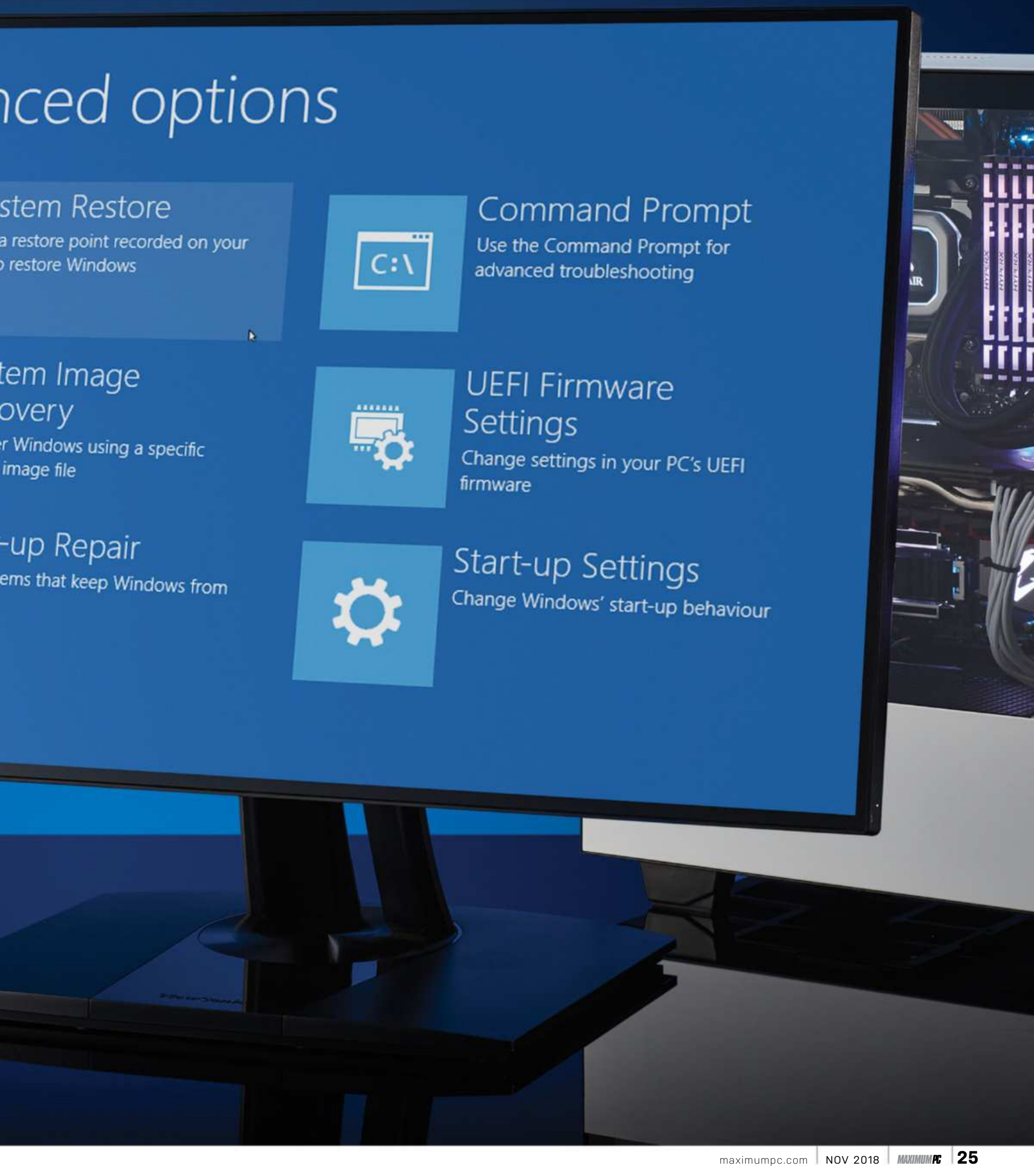
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image file
UEFI Firmware
Settings
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firmware
-up Repair
ems that keep Windows from
Start-up Settings
Change Windows' start-up behaviour

1 THE PERFECT WINDOWS PC

If you're planning to move to Windows 10, installing the OS might be the first area where you run into problems. Installing a new operating system requires a certain amount of free space on your drive, so that it can be downloaded and certain elements can be run successfully.

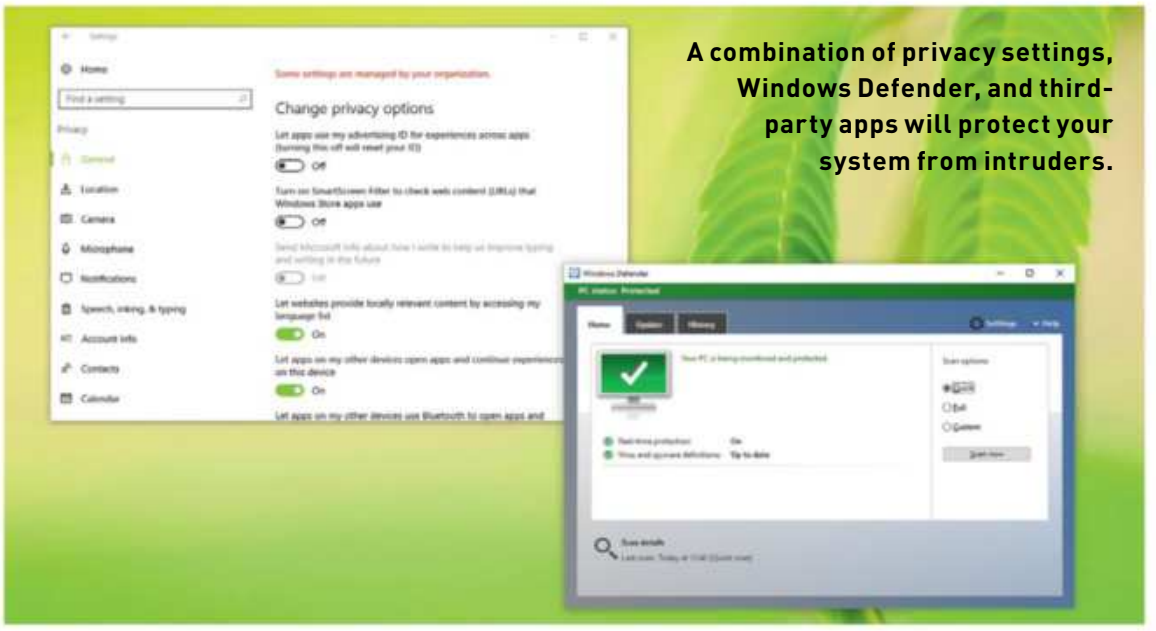
For Windows 10, the minimum space requirement is 16GB, which should be kept free on the main system drive the computer uses. This is actually the same as previous versions of Windows, so if you've upgraded before, you can most likely do it again. To check how much space you have left, go to "My Computer" (or "This PC," depending on the version of Windows you're running), where any drives you have are listed. You can see the remaining space indicated underneath each drive, or you can right-click and select "Properties" for a clearer overview (the system drive is usually C:). Just as with space requirements, your PC also has to be capable of running Windows 10. This means it must reach certain minimum system requirements. Thankfully, the requirements for running Windows 10 are relatively low: a processor of 1GHz or faster; 1GB (32-bit) or 2GB (64-bit) of RAM; 16GB of free drive space; a Microsoft DirectX 9 graphics device; a Microsoft account; and Internet access. To find out your PC's spec, go to "Control Panel" and select "System & Security," then "System."

2 ACTIVATE

Some users have reported issues with activating their copies of Windows 10, which could have been down to a number of different reasons. In some cases, the easiest way to get around the problem is to purchase a legitimate copy of Windows 10.

Unlike previous versions of Windows, this latest one is almost exclusively available online, which means that official Microsoft websites are the best bet for your purchase. The company was once giving the OS away for free, but that promotion has now ended.

Microsoft has a helpful website that provides a downloadable copy in either 32-bit or 64-bit versions. If you find that you're unable to activate Windows 10, Microsoft has introduced an activation troubleshooter; head to "Settings," then click "Update & Security," go to "Activation," and select "Troubleshoot" (you won't see this option if Windows 10 has already been activated).



A combination of privacy settings, Windows Defender, and third-party apps will protect your system from intruders.

3 UPDATES

Windows 10 is, in many ways, a truly Internet-based OS. Mostly this is a bonus, but there are times when it isn't—and Microsoft's attitude toward downloading and installing operating system updates is one such time.

The most annoying part of automatic updates is the restarting, which can seemingly come at random (and inconvenient times). The simplest way to counteract this is to head to Windows Update (in "Settings → Update & Security"), click "Advanced Options," and then "Notify to Schedule Restart," which means the OS will request a reboot rather than trample all over the work you're not quite done with yet. (Turn to page 31 for a more in-depth look at Windows Update.)

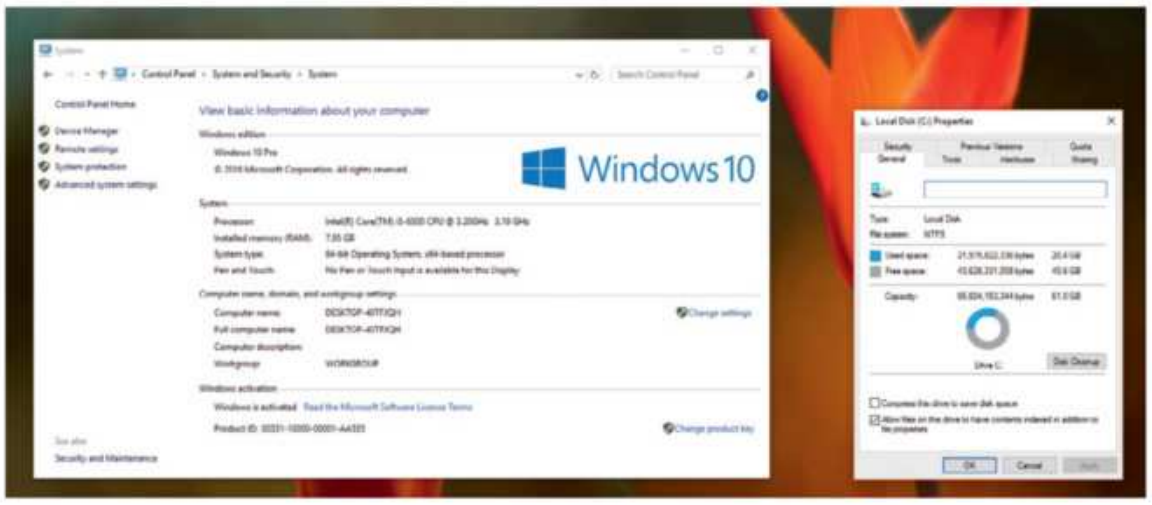
Each version of a new operating system also comes with its own set of backward compatibility issues, and Windows 10 is no exception. The transition from Windows 8.1 to 10 was far less jarring than the move from Windows 7 to 8, but there are still certain applications that can become broken and, in some cases, cease to work at all.

One such application is Chrome, which some users have had to fully delete and reinstall. If a program isn't working with Windows 10, try looking in the Microsoft Store or on the official website for the software to find an update. If that doesn't work, delete and reinstall it. Over time, more and more developers have updated their programs for Windows 10 compatibility, so this is now less of a problem than it was.

4 BROWSERS

The web browser has become the heart of the modern PC. Microsoft ships Windows 10 with Edge, the successor to its Internet Explorer browser (although IE is still present in the operating system). For many people, however, using Chrome or Firefox is the norm, no matter what Microsoft wants.

To install Chrome or Firefox, open Edge, search for either browser, and find a Windows 10 version. Download it, install it, and make sure it's set as the default browser option, so Edge doesn't keep reappearing. To do this, head to "Settings → System," and click "Default Apps"—click



If you want to install a new operating system, make sure your system is up to spec first.

under "Web Browser," and then select your preferred default browser.

If you do want to use Edge, you'll find it's actually a decent browser, but it does come with some annoying features. Because it's a Universal Windows App, Edge runs on smartphones, tablets, PCs, and almost any other device. This means that it sometimes has a problem with being too much like a phone app rather than a PC program.

One of the ways this manifests itself is by sometimes refusing to play media when minimized, just as a phone app wouldn't. There's a fix for this, but it's tucked away in a rather obscure location. Head to "Settings → Privacy → Background apps," and enable Microsoft Edge (switch it to "On") in the list on the right, to enable the browser to keep itself going in the background. There's another issue with Edge, and it's often one of personal taste: Many people just don't like the Bing search engine, most likely because they've always used Google. That's fine, and we're sure Microsoft understands.

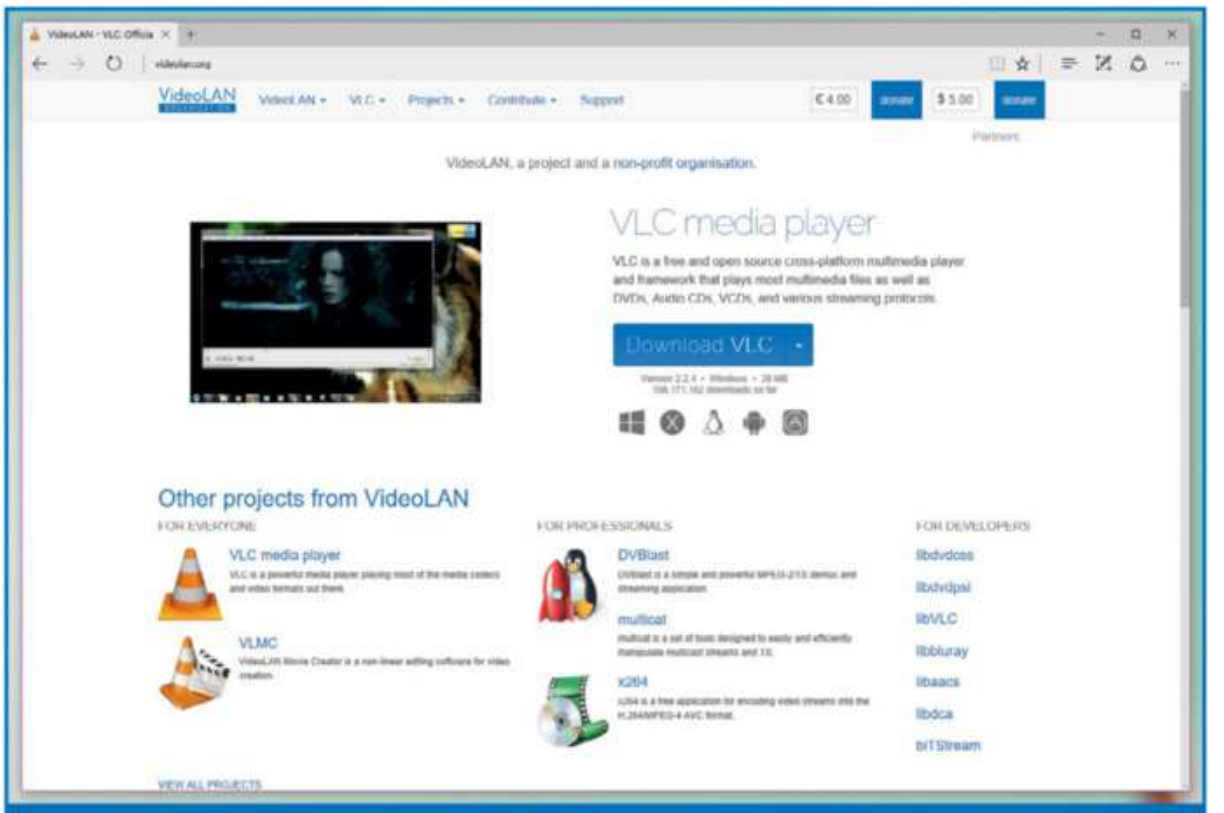
Changing Edge's search engine over to Google is relatively simple. Navigate in Edge to www.google.com (or Yahoo, or whatever your preference), and click the ellipsis (...) in the top-right. A drop-down menu appears: Select "Settings," then navigate down to click "View Advanced Settings." From here, scroll down to "Search in the address bar with..." and select "Add New." Some users have reported that "Add New" often has no results in it, suggesting that no new search engine can be added. This isn't true. To get past this, close and then reopen Edge, and (hopefully) some results will appear. One slight issue: You can't ask Cortana to search with Google; it always uses Bing, which can be something of an irritation.

5 PRIVACY

Data security is incredibly important as hackers become more sophisticated, and the number of complex cyber-attacks is on the up. An unprotected PC is basically an invitation to be interfered with, and you might not know you're being exploited—the days of openly malicious viruses are somewhat behind us.

Windows 10 comes with a decent set of built-in protection measures, but you can never be too careful. One such feature that should be disabled by privacy-minded individuals is Wi-Fi Sense, which automatically shares the Wi-Fi password across Win 10 devices on the same account.

Microsoft updated Wi-Fi Sense to share less data, but switching it off is the ideal way to prevent anything you don't want to happen. Go to the Start menu, select



MEDIA MALADIES

Annoyingly, Windows 10 ships without DVD-playing software. However, Microsoft offers an app from the Microsoft Store called Windows DVD Player, but it costs $14.99. The best bet if you want to watch DVDs is VLC Media Player, which is free to download, and fully supports Windows 10. VLC Media Player also supports a host of other file formats—even the weird ones—making it a very useful tool.

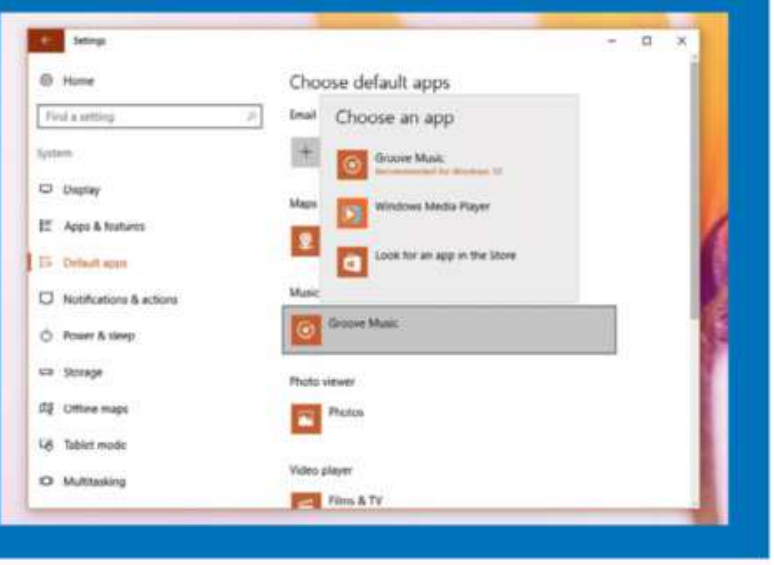
Many of us have moved on from DVDs to the wild world of media streaming. Netflix and Amazon Prime both work on Win 10's default browser, Edge, but may need an update to Silverlight, an application framework that Microsoft created and maintains.

If you've upgraded from a Win 7 PC, you could well suffer from this issue, as the older version of Silverlight may have traveled across when you migrated. So, if you're encountering streaming gremlins, go to the Microsoft website, where you can reinstall Silverlight—follow the instructions as detailed on the web page.

Then there's music. Although Microsoft still bundles Groove Music with Win 10, the service has been deprecated, with Microsoft recommending Spotify instead. However, there are plenty of alternatives, from Google Music to Deezer and Tidal, as well as Apple Music, with a standalone version of Apple's iTunes for Win 10 now available from the Microsoft Store.

Browser-based streaming services—such as Google Music—are also supported, of course, but bear in mind that they may not work well in Edge, as Win 10's browser doesn't stream multimedia when minimized. At any rate, to set the default music service (the one songs automatically play with), head to "Start → Settings → System," and select the "Default Apps" tab. You'll see a "Music Player" section, which presents options based on the players you have installed. Select the one you want, and click "OK."

If you just want to play your existing music collection, then try MusicBee (https://getmusicbee.com). It's easy to use, powerful, and free.



SPEED-UPS

The easiest way to fix a PC booting sluggishly is to reduce the number of apps that launch on startup, as having too many programs firing up when the computer starts makes the whole process much slower, especially when it comes to older hardware.

To trim those apps, press Ctrl-Shift-Esc to bring up Task Manager, then click the link that says "More Details." From here, select the "Startup" tab. Look through the list of enabled apps, and find any that you don't need—you can turn an app off by right-clicking it, and selecting "Disable." Disabled apps don't automatically load on boot up. Be careful not to turn Microsoft services off, though, or important apps, such as antivirus. If you're unsure whether it's wise to disable a certain app, Google it to find out.

Let's think beyond physical speed now, and more toward efficiency. Do you feel as though it takes ages to get anything done in Windows 10? The "Quick Access" menu is located in File Explorer, and it can save a ton of time. To add files, folders, or apps to the sidebar, right-click their icon, and select "Pin to Quick Access." This means they show up and can be easily accessed, which is useful for recently visited folders. You can also set File Explorer to load the "Quick Access" menu by default when you bring it up, rather than "This PC." To do so, with File Explorer open, click the "View" tab in the top menu (next to "Share"), then click "Options," and select "Change folder and search options." Look where it says "Open File Explorer to," and use the drop-down menu to select "Quick Access."

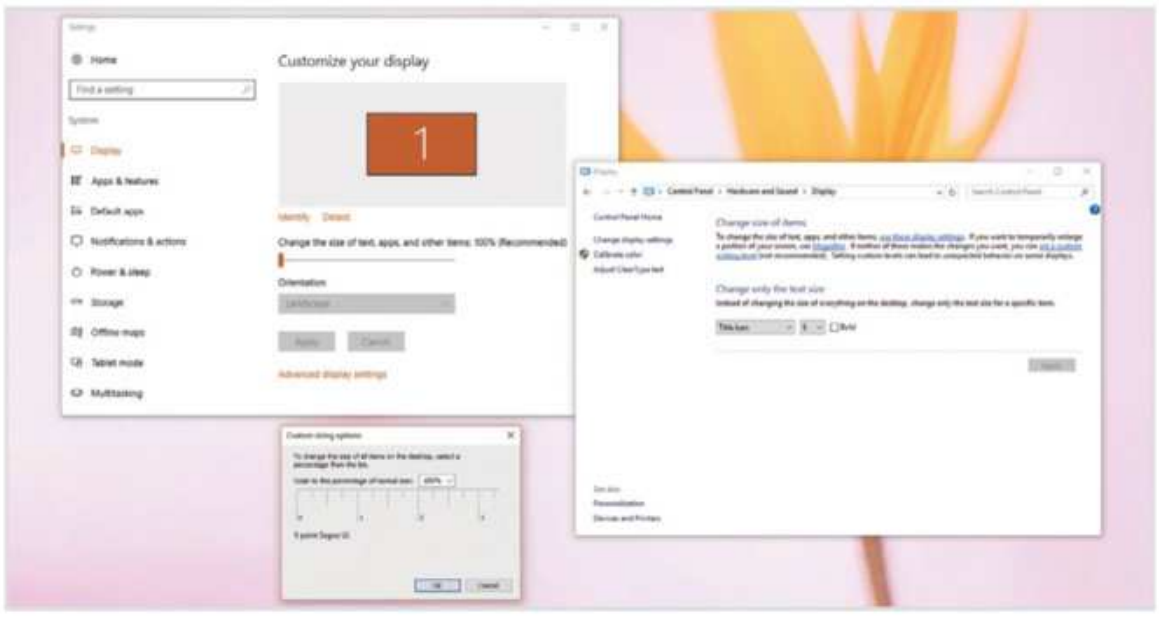
"Settings," click "Network & Internet," then "Wi-Fi," and head to "Manage Wi-Fi Settings"—turn off all the options in here. Also in "Settings," you can get an overview of everything else happening on Win 10 in terms of privacy under the "Privacy" section. Here, you're presented with a bunch of toggles that adjust some privacy options to help keep everything under control.

Windows 10 also ships with a variety of security features that are worth looking at. One such feature to be aware of is Windows Defender, which is designed to detect and remove malware from PCs—it's under "Settings → Update & Security." Make sure you turn it on if you don't have a third-party antivirus solution running. Equally, don't rely on Defender; it's one of the least effective antivirus tools there is, and you should definitely apply some third-party protection, even if it's something free, such as Avira (www.avira.com).

Windows Firewall is the other half of Microsoft's basic efforts to keep your PC safe. It's easy to turn on, but configuring the firewall is a slightly more involved matter.

To switch on the firewall, or rather, to make sure it's switched on as it should be by default, type "firewall" into the search/Cortana box (next to the Start menu), and click "Windows Firewall." From here, there's an option to turn it on (or off), and you can also adjust its relative "strength."

Windows Firewall can be set as incredibly strong via "Advanced Settings"—blocking all suspect apps without asking—or slightly weaker, so there's a slightly greater risk that your PC will be hit by an infection, but the firewall won't interfere as much.



Fix issues with your display by experimenting with the available settings.

6 INPUT ISSUES

If you've bought a Windows 10 machine with a touchscreen, you are, by and large, getting the best experience with the OS. Ever since Win 8, Microsoft has been optimizing its operating system for the finger—and sometimes pen—with large tiles, easy-to-scroll menus, and so on. It can still be a little disjointed, but the way to remedy this is simple: Go to "Start → Settings → System → Tablet Mode." Then turn Tablet Mode on—this optimizes Win 10 for fingers rather than pointers, making it far easier to use.

Having a touchpad-enabled laptop is also good for Windows 10, but some users have reported that the upgrade from Windows 7 (and sometimes Windows 8) breaks it.

One of the ways to solve this is by first checking to see if your keyboard has a key that turns the touchpad off. You usually have to use the Fn key on your laptop with one of the F-keys; look for a symbol that looks like a rectangle with a cross through it.

If your laptop doesn't have such a function—or the right setting is toggled and you're still having issues—head to "Devices → Mouse & Touchpad → Additional mouse options." A new window appears. From here, select the "Device Settings" tab, then "Devices," and make sure the touchpad is enabled. If none of these options work, press Win-X, select "Device Manager," then "Mice and other pointing devices," and update the driver. This should fix things.

7 HARDWARE

We can't all keep up with the latest changes in tech—and neither should we have to—but this can, naturally, cause issues. Let's start with printer compatibility. If you're jumping from Windows 7 (or earlier) to Windows 10, it's definitely worth updating all available printer drivers, which should help prevent them not working post-upgrade. Doing this is simple. Just search Google (or Bing, depending on your preference) for the name of your printer, and download the latest Windows 10 compatible drivers. Follow the manufacturer's instructions to install them, and you're good to go.

Now on to screens. Users have reported issues with high-resolution displays and Windows 10, including experiencing

blurriness in applications that had been rendering fine on previous versions of the OS, such as Windows 8.1.

The easiest way to solve the issue of blurriness is by going to "Control Panel → Display," and fiddling around with the settings here. There is no single setting that will fix all issues, so experiment and see what works (and what doesn't).

To fix blurriness in specific applications, right-click the app's icon, and select "Properties." Under the "Compatibility" tab, there is an option to "Disable display scaling on high DPI settings." Check this and—hopefully—the problems will disappear.

You may also find that your screen is flickering—this isn't always a hardware issue, as some users have found it to occur when upgrading to Windows 10.

The easiest way to fix this is to update all relevant drivers for monitors, as well as Norton Antivirus, iCloud, and IDT Audio, which are all suspected to be potential causes of these problems. It may even help to uninstall and then reinstall them.

Windows 10 does automatically update drivers, so there is also a chance it's forcing an incompatible version of a driver on to the PC without realizing.

If you found that an upgrade to Win 10 broke the connection of a Bluetooth device (or devices) that was previously paired up just fine with your machine, there is an easy fix for this. According to Microsoft, all you have to do is head to Device Manager (just type "device manager" into the search/Cortana box next to the Start menu), select the Bluetooth driver, and update it to the latest version, which will be compatible with Windows 10. The operating system should be able to automatically search, and then update, the driver. If that fails to work, unpairing (or "forgetting") the device before re-pairing it should fix the issue.

8 MOBILE COMPUTING

Battery life is important to anyone who regularly uses a laptop, tablet, or smartphone, and, of course, Windows 10 can be used on all three of those devices. Microsoft recognizes this—as shown by the marketing of its Edge browser as being battery-friendly—and has built several tools into Windows 10 to help cut down on excessive battery drain. All apps that run in the background can be toggled off, for example, which stops them from sucking up precious juice.

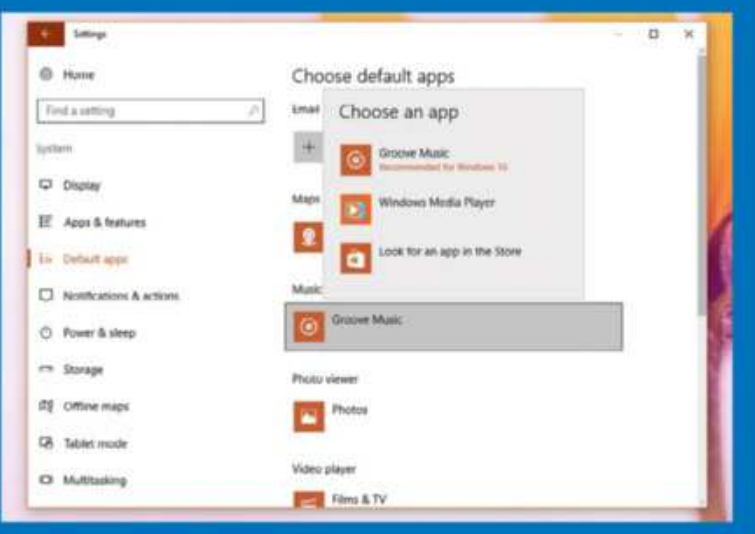
Windows 10 also includes a dedicated set of power options, which you can find via "Settings → System → Power & Sleep." From here, display sleep times can be set,

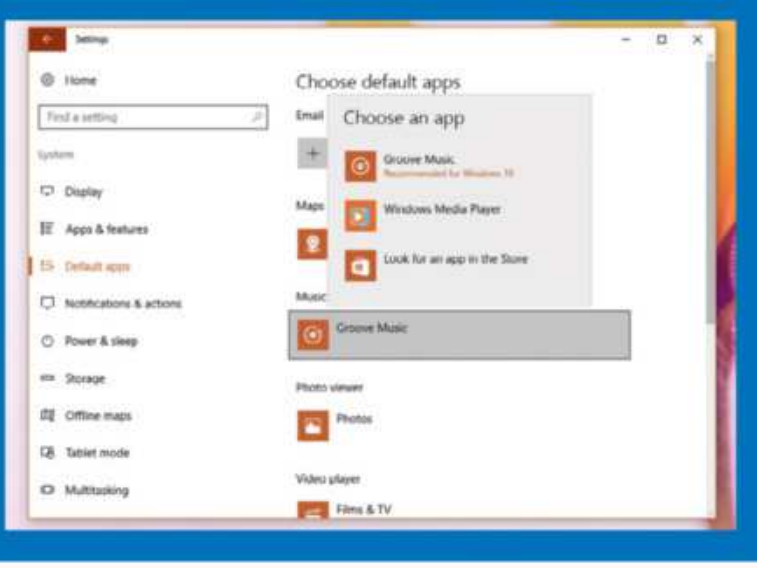
FILE SAFETY

Losing files after disaster hits because you didn't back them up is hugely frustrating, but it can be easily avoided. To create a backup, buy an external storage drive (larger in size than the data you want to store on it). You can copy your files across to this disk manually, or you can set up File History in Windows. To do the latter, ensure the drive is connected to your PC, left-click the "Start" menu, then click "Settings." Click "Update & Security," and navigate to "Backup." See the "Add a Drive" button next to the "+" sign? Click this. Windows scans for available drives, and you should select the one you want to use from the list it brings up. The OS now gets to work; an "On" toggle button shows that the feature is active and automatically backing up your files (and will continue to do so as long as the drive is connected).

If a physical drive doesn't suit you (maybe you're worried about a fire, for instance), there are plenty of online backup options. Backblaze (www.backblaze.com) has received some very good reviews, and comes with various tiers suitable for single PCs right through to businesses. Alternatively, you could simply use a cloud storage locker, such as Dropbox or Microsoft's OneDrive, which is tied in directly with Windows 10.

Whichever online option you choose, do be warned that sending all your files over an Internet connection could be a slow process—although that obviously depends on the quantity of files you have and the speed of your broadband. Also, be careful if you have data allowances on your broadband plan. It can be a good idea to have both a local backup on an external storage drive and a further online backup, even if the latter only holds critical files, not everything.





and under "Additional Power Settings," you can select a power plan that means a lighter load for your battery.

If just fiddling with the settings isn't enough, Windows 10 can also generate a battery report. To do this, head to the Command Prompt Admin (which you get from right-clicking the Start menu), and type "powercfg /batteryreport /output "C:\battery_report.html"." This saves a file to any chosen folder—for example, C:\ in this case, the root of your system drive—which gives you a hugely detailed look at battery quality, cycles, how much charge is left, and much more. The report is a little dense, so be warned.

Location-based apps are fairly prominent in Windows 10, which makes it a good idea to let your PC know where you are. Cortana, for example, can give far more information if it can pinpoint where in the world it's being used.

To update your location settings, head to the Start menu, click "Settings → Time & Language," then click "Region & Language," and make sure the correct country is selected. To turn on Location services, go to "Settings → Privacy → Location," and flick the "Location" switch to "On."

If you're on a tablet that has 4G, or if you're using a mobile hotspot, or surfing the web via a 4G-enabled laptop, the operating system may have a nasty surprise for you. Users have been reporting that the default configuration of Windows 10 sucks up data like there's no tomorrow, potentially going over your data allowance, and leaving you with a hefty bill. Fortunately, there's an option that addresses the problem. Go to "Settings → Network & Internet → Wi-Fi." Click "Advanced Options," then "Set as metered connection" to stop Windows 10 collecting so much data in the background.

9 MAJOR CRASHES

While Windows 10 is far more stable than many OSes that came before it, it's still prone to the odd bout of madness, so it pays to be prepared. A black screen on Windows 10 can mean several things, depending on whether you've logged in to the OS or not.

If you haven't logged in, or Win 10 hasn't booted, your immediate diagnostic path should be to check your Internet connection, then boot your PC in a different way. If you logged in, then the screen went black, unplug all external devices and, failing that, boot via Safe mode. It's just what you'd expect—a safe way of booting up a PC and running the system with no startup apps and only essential drivers, which should hopefully enable the computer to boot successfully (when it won't otherwise, due to some issue or other). With Windows 10, to access Safe mode, hold down Shift while booting up (or select "Restart" from the desktop while holding down Shift), then follow the menus on screen.

A problem has been detected and Windows has been shut down to prevent damage
to your computer.
PFN_LIST_CORRUPT
If this is the first time you've seen this Stop error screen,
restart your computer. If this screen appears again, follow
these steps:
Check to make sure any new hardware or software is properly installed.
If this is a new installation, ask your hardware or software manufacturer
for any Windows updates you might need.
If problems continue, disable or remove any newly installed hardware
or software. Disable BIOS memory options such as caching or shadowing.
If you need to use Safe Mode to remove or disable components, restart
your computer, press F8 to select Advanced Startup Options, and then
select Safe Mode.
Technical information:
*** STOP: 0x0000004e (0x00000099, 0x00900009, 0x00000900, 0x00000900)

The Blue Screen of Death isn't as bad as it sounds—a fix can usually be found.

The Blue Screen of Death, also known as a BSOD or stop error, may sound bad, but it's certainly fixable in the majority of cases. When the problem manifests, it halts your PC completely, stopping it working, and showing a blue screen, usually with some kind of message about restarting or a critical error. You then need to reboot.

To fix this, you can explore several options. First, check how much available space you have left on your system drive, and if it's low, make some room by deleting bigger files or programs you don't need. Also, ensure all the latest updates are applied to the software on your machine, because having outdated apps can cause issues. While you're at it, update the hardware drivers of any peripherals, as the problem could be caused by Win 10 clashing with something. Head to "Device Manager," which you can reach by searching for it in the Start menu. Here, you can ensure that peripherals such as your monitor, webcam, printer, or scanner have the latest drivers, simply by right-clicking the device in question. Select "Update Driver Software," then click "Search automatically for updated driver software."

10 GLITCHES

It's not uncommon for certain software, particularly older apps, to encounter glitches or even fail to run completely with Windows 10. There's one potential way to get around show-stopping bugs, though: Right-click the icon for the app, select "Properties," then click the "Compatibility" tab. From here, click the checkbox next to "Run this program in compatibility mode for," and in the drop-down menu underneath that, choose the version of Windows that the program previously ran fine on. Over time, many developers update their apps to remove bugs, so the software in question may eventually work perfectly well with Windows 10. An easy way to help this process is by reporting any bugs you come across—this can usually be done via the developer's website.

Alternatively, your machine may be in the grips of slowdown—perhaps your hard disk is whirring away like crazy? If so, there's a good chance that one of the programs you're currently running has developed some kind of issue, and is sapping all of your system resources. Luckily, there's a very simple way to find out whether an app has gone haywire and is bogging down your computer: You need to head over to Task Manager (press Ctrl-Shift-Esc together), and click "More Details"—you'll then see a list of processes, which is all the different apps and services that are running on your machine. Scan down the list, and look for any apps that are hogging CPU, memory, or disk usage—or perhaps all of the above.

Once you've discovered the culprit, select it. There's an option in the bottom-right corner to "End Task." However, be careful that you aren't ending important system-critical tasks—usually ones with confusing names that don't mean anything to you—because this could cause your computer to crash.

If in doubt, Google or Bing is your friend here—open your web browser, search for the app/service you need information on, and you'll almost certainly find an answer about exactly what it does.

HOW WINDOWS UPDATE WORKS

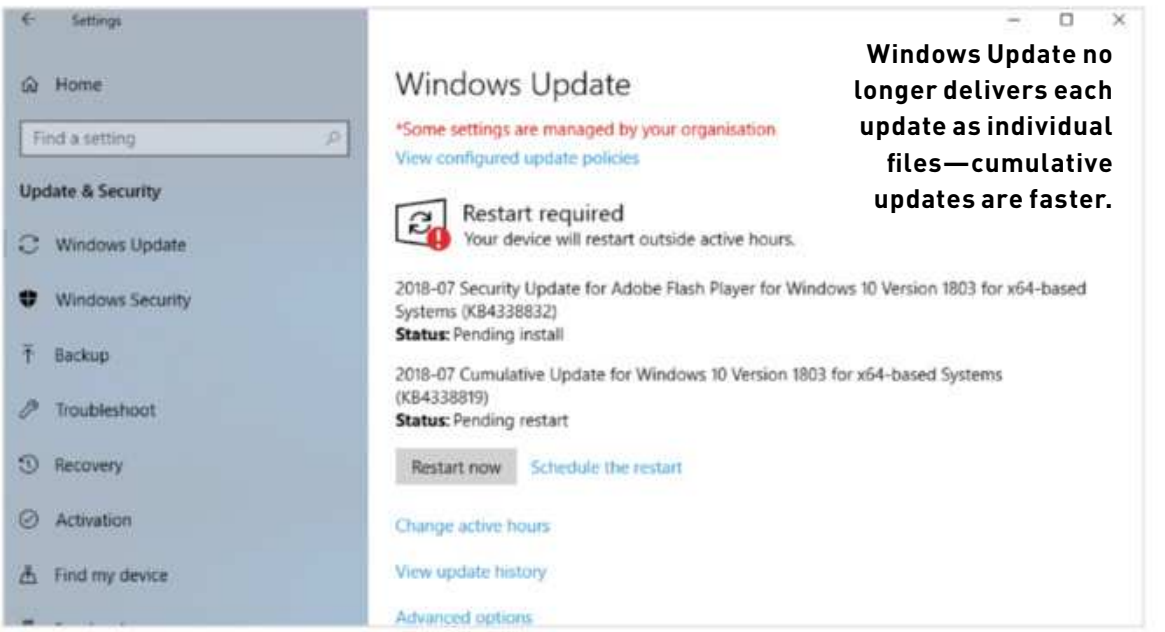
Let's start things off by explaining exactly what Windows Update does—and how it works

Windows Update is designed to keep your copy of Windows up to date through the delivery of special files that "patch" it. The most obvious updates are security hotfixes, which patch vulnerabilities and security holes that could be exploited by malware, as well as bug fixes to resolve specific issues.

Windows Update also delivers bigger updates—what once were Service Packs, then point releases (Windows 8.1), have now evolved into feature updates, delivered bi-annually to add new features, and change the way existing features work. The latest feature update is the April 2018 Update (version 1803), set to be superceded in the fall by the October 2018 update.

There are also "optional" updates, which include other Microsoft tools, such as the .NET Framework, as well as signed hardware drivers, which have been tested and verified to work well with Windows. Some updates are "recommended," and so sit alongside important updates by default. All optional and recommended updates can be clearly found in the Windows Update tool in Win 7 and 8.1, but they're hidden from view in Win 10. We'll show you how to find, review, and install optional updates easily.

Windows Update can also be extended to include updates for other Microsoft products, such as Office, or software for controlling Microsoft keyboards and mice.



Windows Update no longer delivers each update as individual files—cumulative updates are faster.

These days, updates are packaged up and delivered to reduce their size and number, based on what's installed on your PC. A "Full" update contains all the updates released since the last major version of Windows (such as Windows 8.1 or the Windows 10 April 2018 Update). This is typically required after you've just installed or reinstalled the latest version of Windows.

"Delta" and "Express" updates work in a similar way—so much so that Microsoft will be retiring Delta updates as of February 2019, so we'll focus on Express. Express updates are differential—they're generated on demand after Windows Update examines your PC, to contain only those updates not yet installed. This means they're smaller, so are faster to download and install.

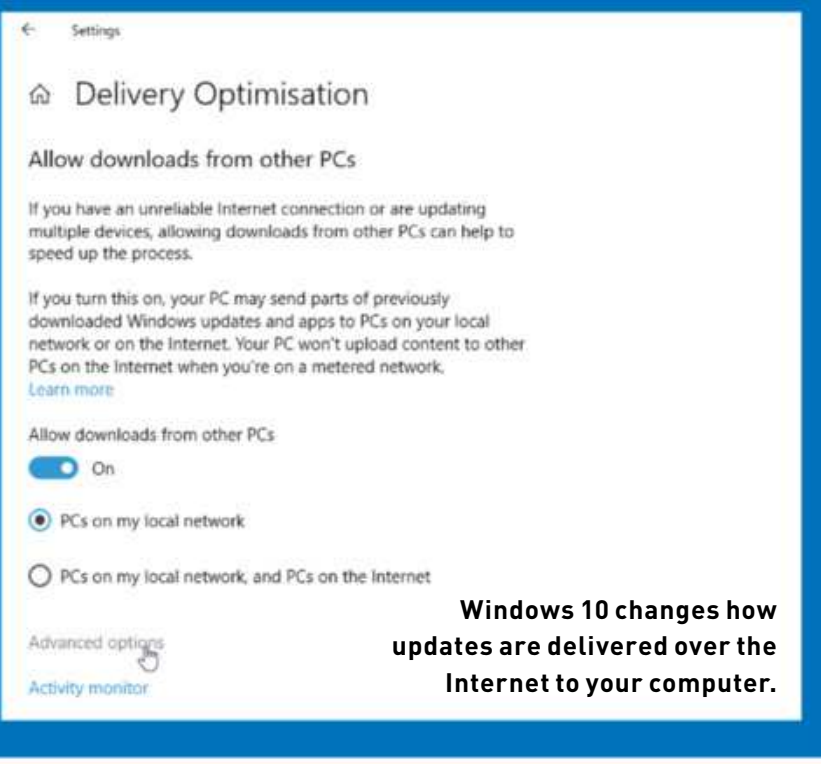
Since 2016, Windows 7, 8.1, and 10 have received updates on a monthly basis—"Patch Tuesday." These contain all security and bug fixes developed over the past month, along with any updates missing from your PC from previous months.

WHAT'S DELIVERY OPTIMIZATION?

Windows 10 users need to be aware of a feature known as Delivery Optimization, which affects how Microsoft delivers updates to PCs over the web. Head to "Settings → Windows Update → Advanced options," and click the "Delivery Optimization" link. Here you'll see a setting called "Allow downloads from other PCs," which basically means that when the feature is switched on (as it is by default), it's possible to receive your Windows updates using peer-to-peer technology from files stored on other PCs across your network and the Internet. In turn, these files can also be sent from your PC to other computers, too.

Click "Activity monitor" to review how much data is being transferred and how much bandwidth is being used, then click "Advanced options" to set manual limits that should help prevent your connection from becoming overwhelmed.

Better still, switch the feature off completely if you're the only PC user in your home. If not, change the setting to "PCs on my local network," so you can speed up deploying updates to other PCs without having to open them up to the wider web.


Settings
Delivery Optimisation
Allow downloads from other PCs
If you have an unreliable Internet connection or are updating multiple devices, allowing downloads from other PCs can help to speed up the process.
If you turn this on, your PC may send parts of previously downloaded Windows updates and apps to PCs on your local network or on the Internet. Your PC won't upload content to other PCs on the Internet when you're on a metered network.
Learn more
Allow downloads from other PCs
On
PCs on my local network
PCs on my local network, and PCs on the Internet
Advanced options
Activity monitor

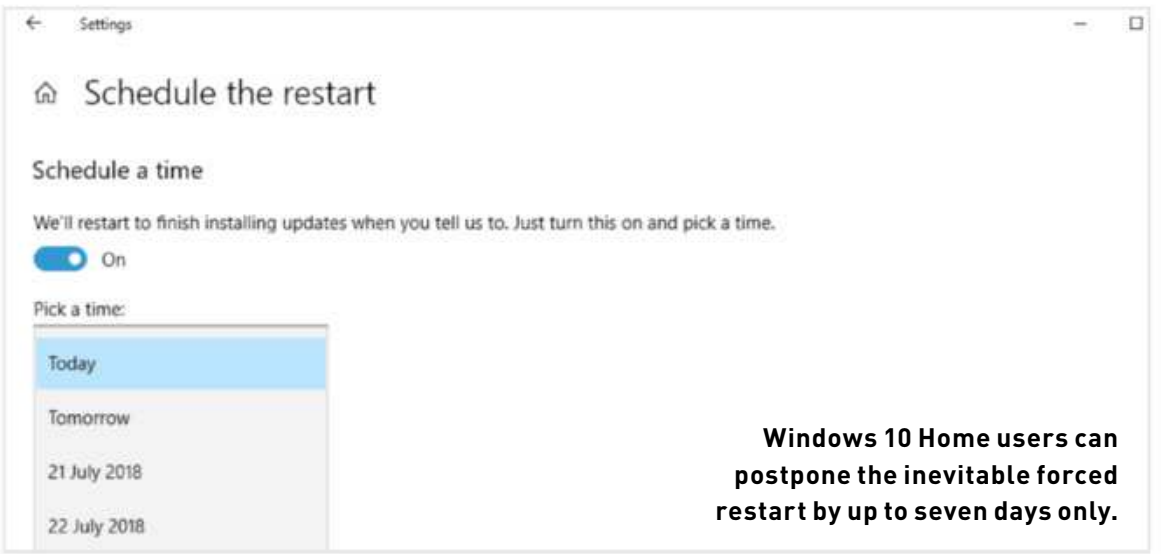
Windows 10 changes how updates are delivered over the Internet to your computer.

TAKE CONTROL OF UPDATES

Discover how to use Windows Update, and wrest back control of the update process from Windows 10

Updating Windows is an incredibly important part of your day-to-day maintenance, but many people put off the updating experience—if they can. This isn't laziness—Microsoft has quite the reputation for releasing patches before they are ready for general consumption, and there are horror stories of Windows installations falling over (turn to pages 34–35 for troubleshooting help).

Despite this, in most circumstances it pays to ensure you're at least up to date with the latest security hotfixes, so opting out of updates altogether—even where possible—isn't practical. Let's see what you can do about ensuring the Windows Update process works with you and not against you.



Windows 10 Home users can postpone the inevitable forced restart by up to seven days only.

TAKE BACK CONTROL

When Microsoft released Windows 10, it took control away from the end user running Windows 10 Home, and now forces updates to be installed as soon as they are available and downloaded. At this point, Windows tells you that updates are pending, and prompts you to restart your PC.

It's configured to force a reboot to install updates outside your "active hours"—in other words, when you're not typically using your PC, which is 5pm–8am by default (click "Change active hours" from the main Windows Update settings screen to change them). It means you can't delay an update indefinitely simply by refusing to shut down or restart, but you can defer it slightly: Click "Schedule the restart" next to the "Restart now" button, flick the switch to "On," and you can choose to push back the restart by up to seven days. It's fine as a last resort, but can you really go for seven days without needing to restart or shut down your PC?

You'll have an easier time if you use Windows 10 Pro: Go to "Settings → Update & Security → Windows Update," and click "Advanced Options." The "Pause Updates" switch allows you to pause updates for up to 35 days—handy if you hear of an update causing problems, and want to put it off.

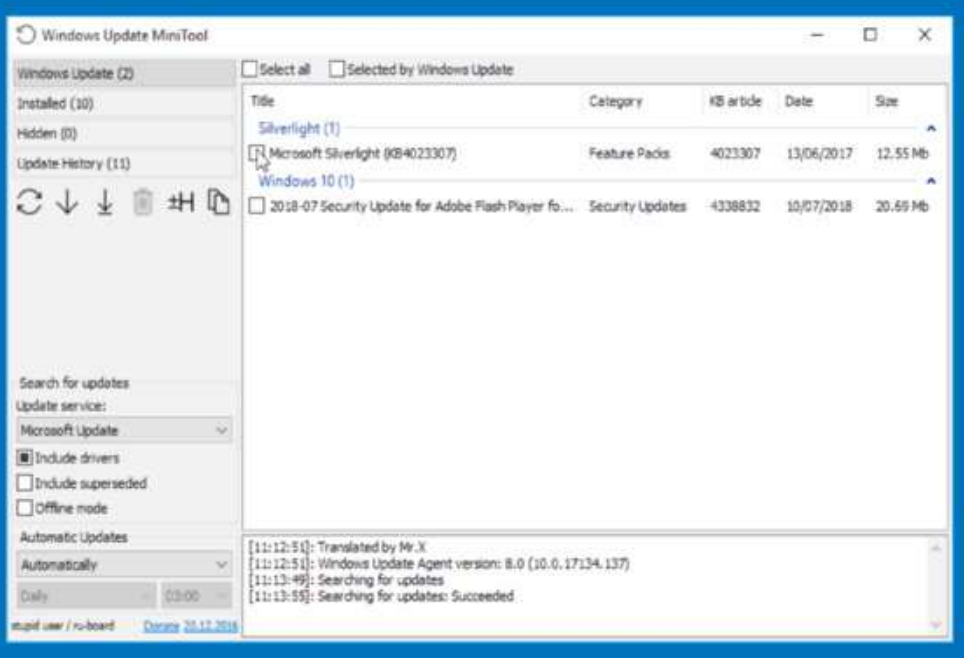
A better way to prevent updates from getting on your system before they're ready is to scroll down to "Choose when updates are installed." You can delay feature updates by around four months after their release by switching from the "Semi-Annual (Targeted)" channel to "Semi-Annual" via the drop-down menu. You can defer this for up to an additional 365 days via the "Feature Update Defer" drop-down menu. It's also possible to defer quality updates—patches and security hotfixes—for up to 30 days via another drop-down menu. That way, you

OPTIONAL UPDATES

Windows Update provides "optional" updates that include additional components, such as Silverlight. They also include Microsoft-delivered drivers for a wide range of hardware. Windows 7 and 8.1 users can review and install these via Windows Update, but these updates are hidden from view in Windows 10—installing driver updates is a hit-and-miss affair, involving going into Device Manager and clicking "Update Driver" within the "Driver" tab of selected devices.

To see what's available—and install it—download the Windows Update MiniTool (http://bit.ly/2v9BwtK). Extract its contents, then run wumt_x64.exe (64-bit) or wumt_x86.exe (32-bit), depending on your Windows system type. Click "Check for updates" under "Update History" after verifying "Include drivers" is selected. Select the updates you want, and click "Install Updates" to install them.

It's also possible to hide unwanted updates here—if you're struggling with an update that repeatedly refuses to install, hiding it stops Windows attempting to install it time and time again.



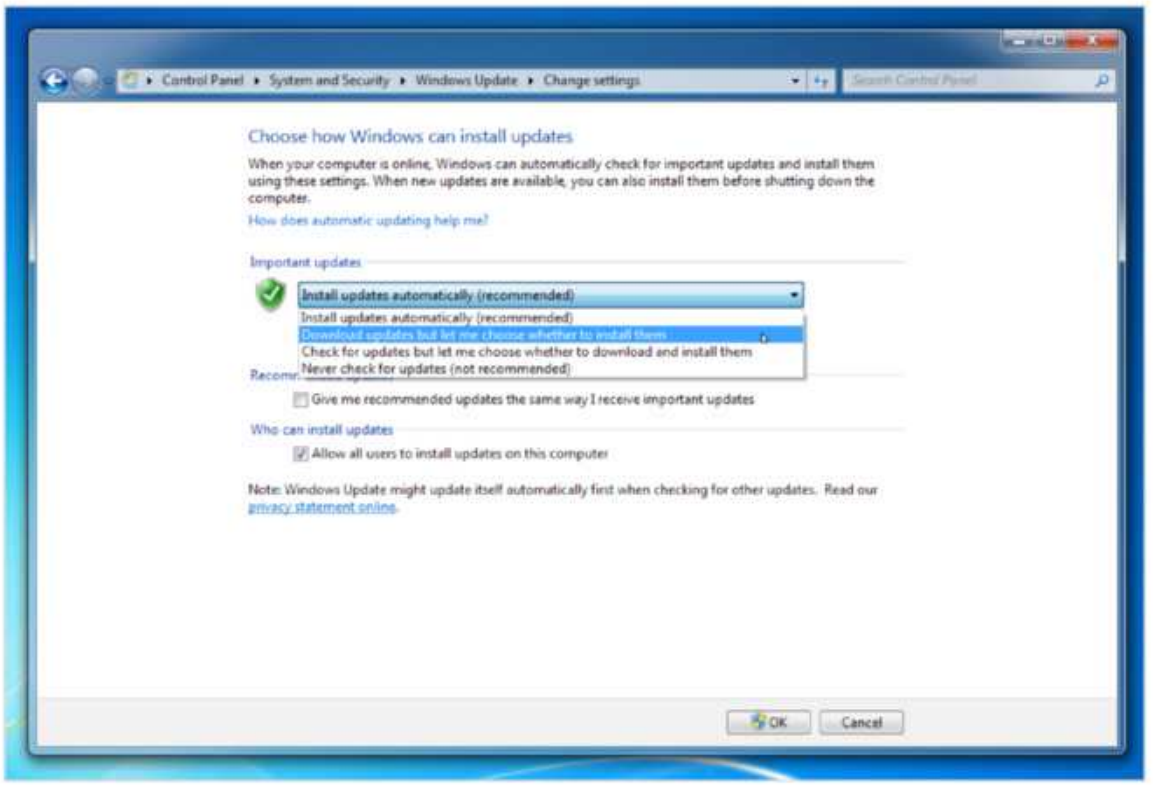
See what optional updates—including signed drivers—are available in Windows 10 with the Windows Update MiniTool.

can avoid exposing your PC to an update that's later pulled for stability reasons.

What if you're running Windows 10 Home? The step-by-step guide below reveals a technique for manually disabling Windows Update that works for the latest April 2018 Update. Note, you should still periodically check for updates—launch the tool and re-enable the service to do so, then disable it again after use.

WINDOWS 7 AND 8.1

If you're still using Windows 7 or 8.1, you remain in full control of the process. Open "Control Panel → Windows Update," where you'll see a screen telling you how many updates are waiting to be installed. Click "Check for updates" to refresh this search at any time. Updates are divided into two types: important and optional. You're shown how many of each are available—click the relevant hyperlink to view and select which ones to install using the check boxes. For more information about a specific update, select it for a summary, then click "More information" for a full description online.


Control Panel ▸ System and Security ▸ Windows Update ▸ Change settings
Choose how Windows can install updates
When your computer is online, Windows can automatically check for important updates and install them using these settings. When new updates are available, you can also install them before shutting down the computer.
How does automatic updating help me?
Important updates
Install updates automatically (recommended)
Install updates automatically (recommended)
Download updates but let me choose whether to install them
Check for updates but let me choose whether to download and install them
Never check for updates (not recommended)
Give me recommended updates the same way I receive important updates
Who can install updates
Allow all users to install updates on this computer
Note: Windows Update might update itself automatically first when checking for other updates. Read our privacy statement online.
OK
Cancel

Windows 7 and 8.1 users enjoy complete control over how and when updates are delivered.

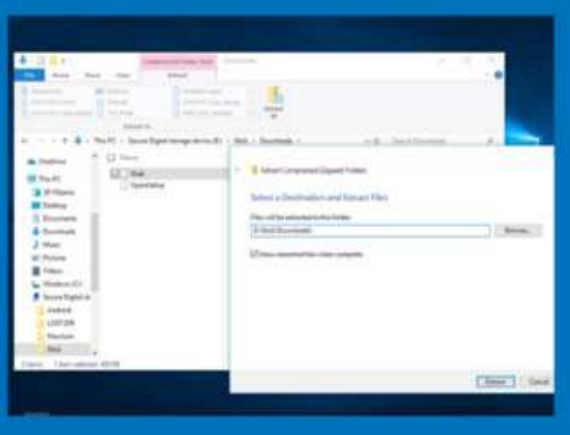
> "At this point, Windows will tell you that updates are pending, and prompt you to restart your PC."

You'll also see a status about whether the update has been downloaded or not, and whether it's ready to be installed on your PC. This status ties into how you've configured Window Update. Click "OK" to return to the main screen, then click "Change settings" to control when and what updates are deployed to your computer.

By default, updates are installed automatically either at a set time or when you next reboot, but if you want to pause before installing them, we recommend choosing "Download updates but let me choose whether to install them." You can also review available updates before downloading them, or switch the feature off entirely—we don't recommended doing this, however, since both Windows 7 and 8.1 are still supported by security hotfixes, so should be kept up to date.

You'll also see a box allowing you to opt out of automatically receiving "recommended" updates alongside critical ones. Unchecking this box means recommended updates like the .NET Framework Tool are moved to the "Optional" category, where they're italicized to make them stand out (see the "Optional updates" boxout opposite).

SWITCH OFF WINDOWS UPDATE

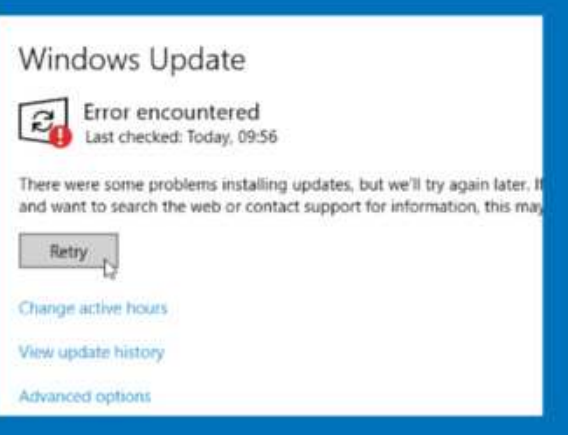


1. DOWNLOAD AND RUN

Download the Windows Update Blocker tool from www.sordum.org/9470/—the gray "Download" button is just above the "Related Posts" section. Once downloaded, right-click "Wub.zip" and choose "Extract All." Next, double-click "Wub.exe" inside the extracted folder to launch the program.

2. SWITCH OFF SERVICE

A small window appears. Select "Disable Service," and verify that "Protect Service Settings" is checked. Click "Apply Now," and the status should change to a red shield with an X, indicating it's been disabled. Reboot your PC—note any updates already awaiting a reboot will still be installed.


Windows Update
Error encountered
Last checked: Today, 09:56
There were some problems installing updates, but we'll try again later.
and want to search the web or contact support for information, this may
Retry
Change active hours
View update history
Advanced options

3. CHECK FOR UPDATES

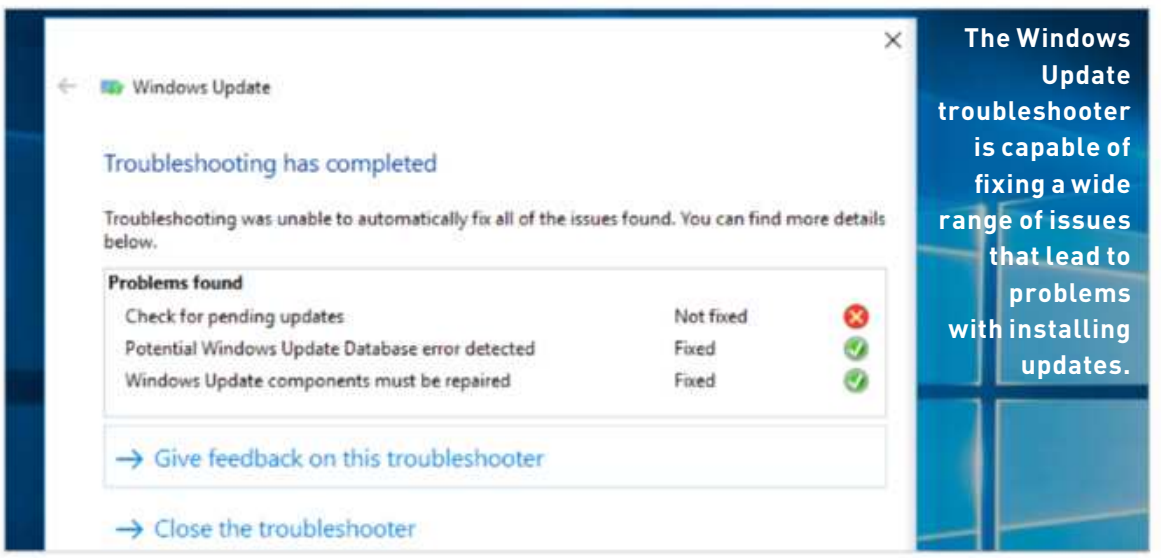
After rebooting, reopen Windows Update Blocker and verify that the service is still disabled. Go to "Settings → Update & Security → Windows Update," where you should find everything appears normal, but click "Check for updates," and you'll see an error, indicating it's been disabled.

TROUBLESHOOT UPDATES

Sometimes the worst happens, and an update goes wrong—just follow these tips to get out of trouble

Ideally, Windows Update should be virtually invisible—other than alerting you when updates are ready to be installed, and while they're being configured on startup.

In the real world, we all know better, of course. Some Windows updates might require two or three attempts before finally installing, while others may stubbornly refuse to install, period. Windows Update might even stop functioning completely, or your PC may suddenly refuse to reboot after you've installed the latest updates. So, what's the solution?


Windows Update
Troubleshooting has completed
Troubleshooting was unable to automatically fix all of the issues found. You can find more details below.
Problems found
Check for pending updates
Not fixed
Potential Windows Update Database error detected
Fixed
Windows Update components must be repaired
Fixed
Give feedback on this troubleshooter
Close the troubleshooter

The Windows Update troubleshooter is capable of fixing a wide range of issues that lead to problems with installing updates.

GENERAL TROUBLESHOOTING

If Windows Update refuses to work correctly—it throws up errors when you attempt to install or scan for updates, for example, or you're struggling to install a specific update—start by running the Windows Update troubleshooter. In Win 10, go to "Settings → Update & Security → Troubleshoot," click the "Windows Update" link, and click "Run the troubleshooter." Older versions hide the troubleshooter under "Control Panel → System and Security → Action Center → Troubleshoot common computer problems."

When the wizard opens, click "Advanced" and choose "Run as Administrator," before clicking "Next" (Windows 7/8.1 only). Wait while the tool scans for issues—if it finds and fixes any, click "View detailed information" if required, to find out more, then click "Close," reboot, and try again. If the fix involves installing pending updates, but it's those updates refusing to install that is causing the problem, click "Skip this fix" to keep searching for other potential issues.

If the problem persists, you may need to perform more drastic steps. The "Reset Windows Update" guide opposite explains how you can use the Windows Repair Tool to get around this—download and install the tool (or extract the portable version) from www.tweaking.com. It will attempt a deeper fix via Safe mode.

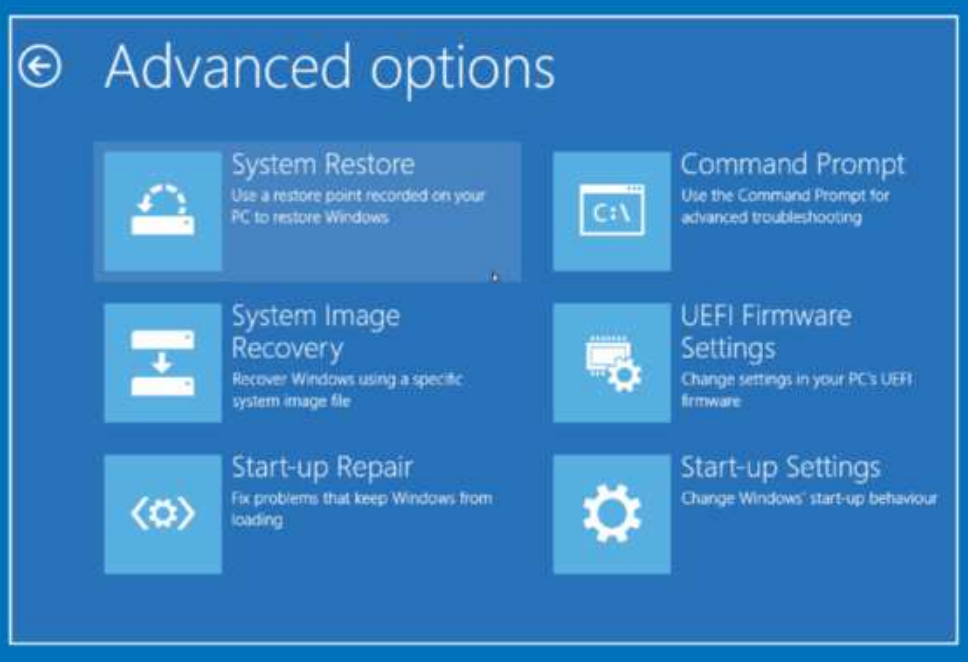
Often, the problem isn't with Windows Update itself, but a specific update that refuses to install. You may get advanced warning—a message during reboot that Windows is reversing a failed update—or your PC may keep attempting to install updates after every reboot. If the problem persists over two or three reboots, it's time to take further action.

Check the status of updates via the Windows Update tool. Simply click "View update history," where you'll see a list of previously installed updates and whether

WINDOWS WON'T BOOT!

It's rare for updates to screw your system up so much it can no longer boot into Windows. After several failed attempts, Windows should give you the option of booting into Safe mode, or bring up the recovery menu. From here, try "Startup Repair" or "System Restore" to roll your PC back to the restore point taken before the update was installed. Note: This may not be an option if you're running Windows 10 and didn't switch System Restore back on after installing the April 2018 Update.

Other options involve recovery media—if you regularly back up using a tool such as Macrium Reflect Free (www.macrium.com/reflectfree), roll back to your last backup using its boot media. Or you could boot from your Lazesoft Recovery Suite rescue media (http://bit.ly/2LtlgPq), and try its Windows Recovery tool. If it fails, use the Data Recovery component to save your data, or take a disk image before booting from your Windows rescue or installation media, and try a repair install; this involves installing Win 7 over the top of itself, or performing an "upgrade install" with Win 8.1 and 10 boot media.


Advanced options
System Restore
Use a restore point recorded on your PC to restore Windows
Command Prompt
Use the Command Prompt for advanced troubleshooting
System Image Recovery
Recover Windows using a specific system image file
UEFI Firmware Settings
Change settings in your PC's UEFI firmware
Start-up Repair
Fix problems that keep Windows from loading
Start-up Settings
Change Windows' start-up behaviour

System Restore—if it's working and accessible—is your easiest route to undoing a catastrophic failed update.

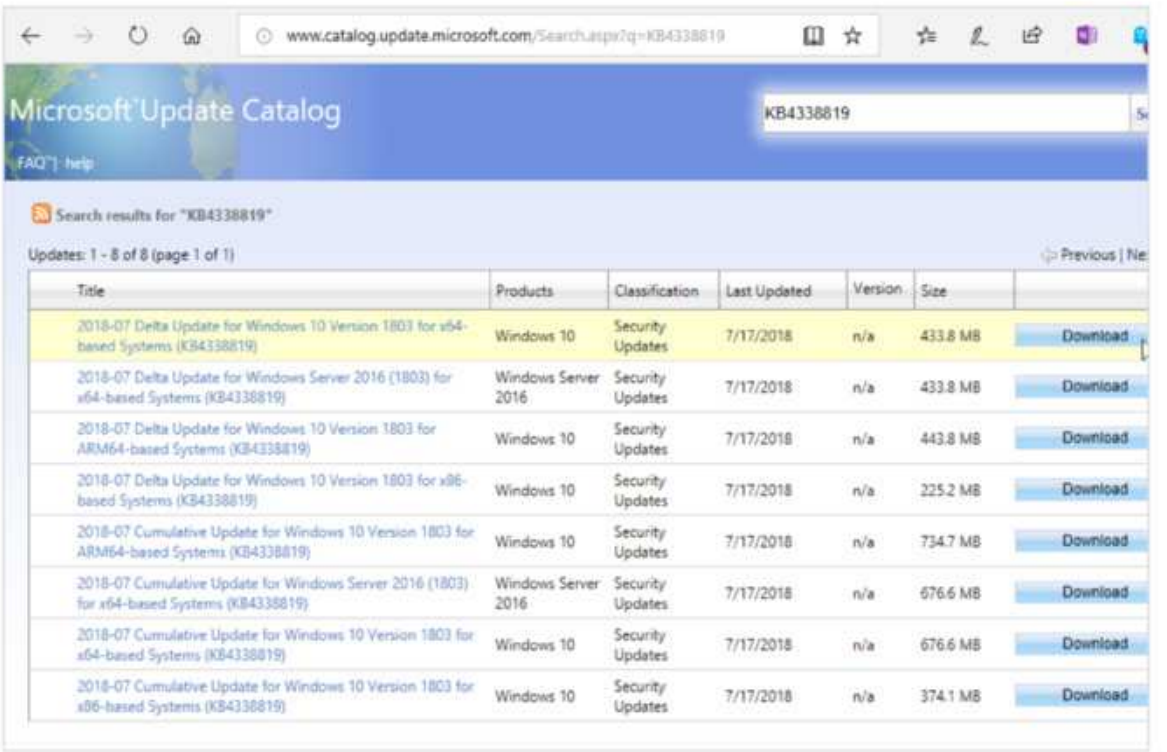
they were successful or not. If there are multiple updates failing, it's likely only one of them is the culprit. Windows 8.1 and 7 users can click to review updates, then select updates one at a time. This may be enough in itself (four stubborn updates on our Windows 8.1 PC all installed singly with no issues, having failed to install together), or it will at least narrow down your search to the specific malfunctioning update.

Another possible fix is to download and install the problem update manually. Search for the update number (including KB) at www.catalog.update.microsoft.com. You're given a list of matches based on Windows version, plus system architecture—x64 is for 64-bit versions of Windows, x86 for 32-bit. Download the file, double-click it, and follow the instructions to install it.

If this doesn't work, then you'll need to dig deeper. Any failed updates are accompanied by an error code in Windows 10; Windows 8.1 and 7 users need to double-click a failed update to review an error report including the error code. Older versions of Windows also provide a "Get help with this error" link, although this usually fails to yield any meaningful results.

Instead, make a careful note of the error code and the update KB number. Google the code—try it with "Windows Update," your version of Windows, the KB number, or just on its own to see what you find. Ignore ads and focus on genuine websites, including reputable sources such as https://answers.microsoft.com. Focus on newer results first—particularly if they correspond to your specific KB number.

With a little luck, you'll stumble upon a solution that's been found by other users. There's no rhyme or reason to certain updates failing, but if all of the troubleshooting techniques we've described here—including the Windows Repair tool—fail to yield a solution, don't panic. Simply ping our resident troubleshooting master an email at doctor@maximumpc.com, and he'll see if he can steer you toward the solution.



Be sure to select the correct version of Windows when downloading updates manually.

"You may get a specific warning that Windows is reversing a failed update—or your PC may keep attempting to install updates after every reboot."

RESET WINDOWS UPDATE

1. USE SAFE MODE

Press Win-R, type "msconfig," and press Enter. Switch to the "Boot" tab, and check "Safe boot," selecting "Network." Click "OK → Restart." Once in Safe mode, launch Windows Repair (www.tweaking.com) and work through the basic checks—ignore the power reset if your PC is otherwise OK.

2. PERFORM PRE-CHECKS

The other three steps—pre-scan, disk check, and System File Checker—are all essential in case your Windows Update problem is linked to disk errors or has missing or corrupt system files. Work through them, rebooting where prompted, then returning to that point in the program.

3. APPLY REPAIRS

Once done, click "Backup" to back up the Registry, and "Create" to create a system restore point. Next, you're prompted to open Repairs or select a preset —select "Preset: Windows Update." Click "Start Repairs." When done, return to msconfig, and uncheck "Safe boot" before rebooting.

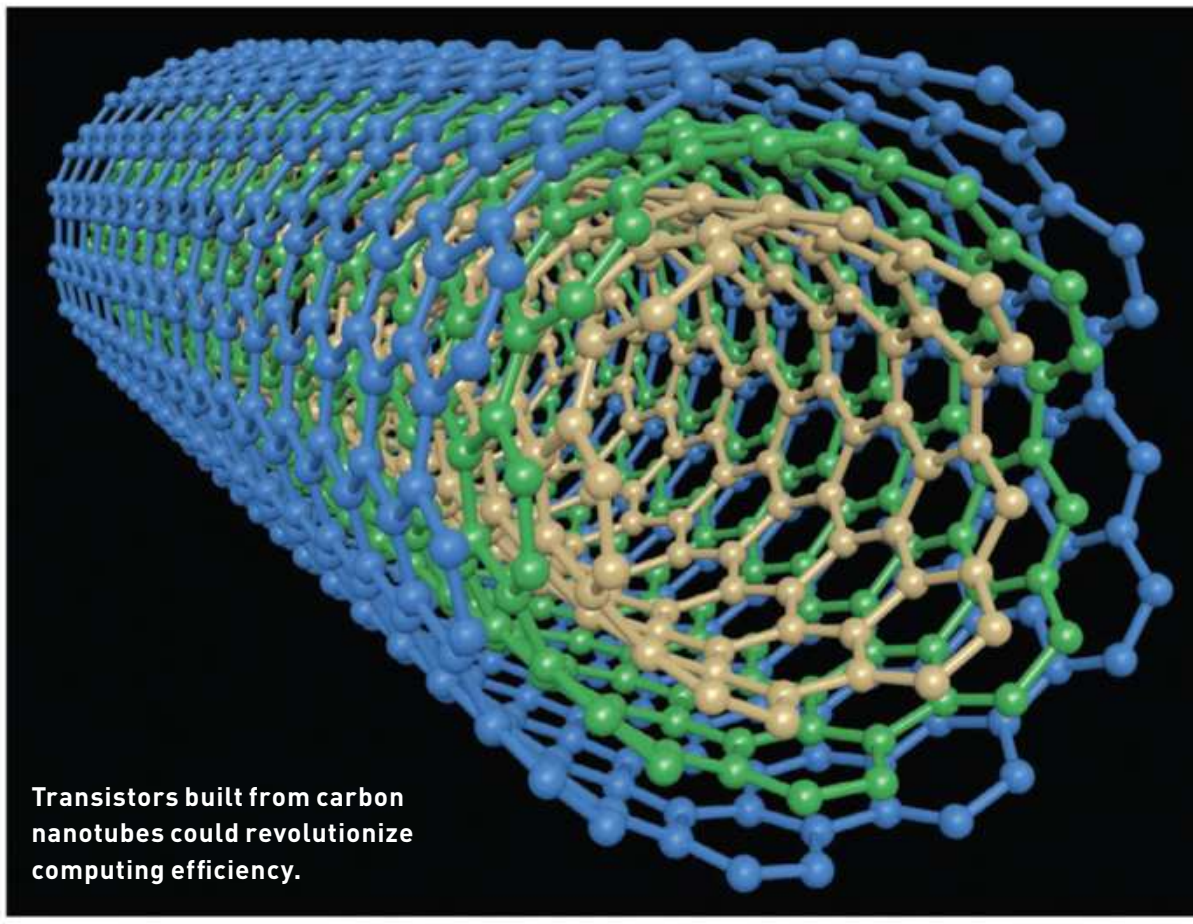
THE FUTURE OF COMPUTING, MOORE OR LESS

It's had a very good run, but Moore's Law is done, dusted, and dead. *Jeremy Laird* investigates the future of computing in the post-exponential era

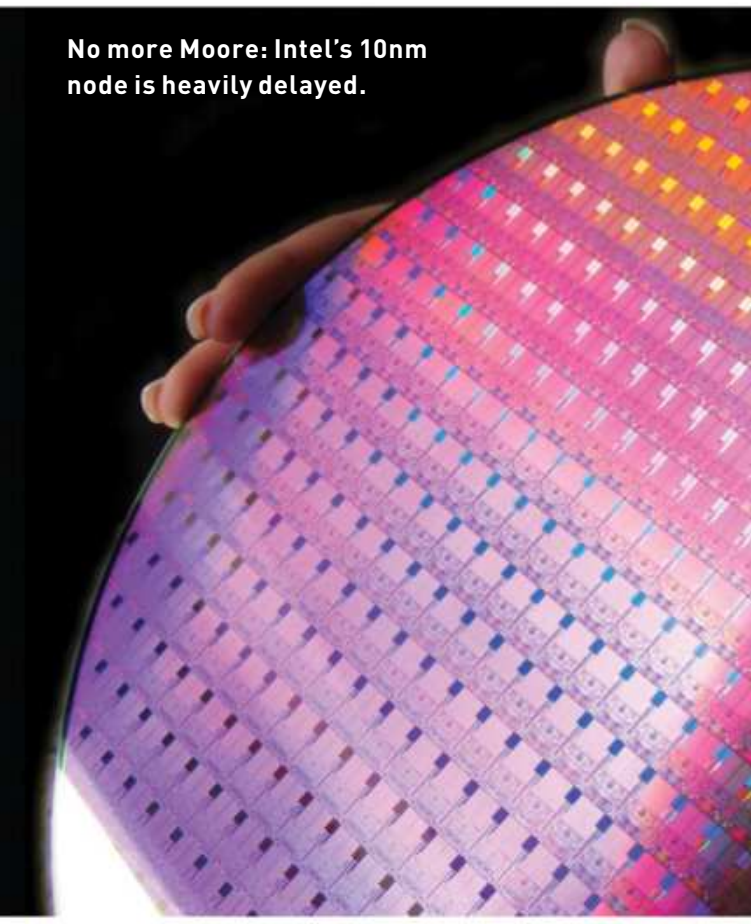
FIFTY YEARS IS A LONG TIME for any prediction to hold true. It's an aeon when it comes to predicting the future of cutting-edge technology. But it's pretty much how long Moore's Law has held together as a predictor of progress in computing power. But now just about everybody agrees that Moore's Law is done. Computer chips are no longer doubling in complexity every two years. Intel's most recent roadmap update, to take just one example, pushed volume shipments of its next-gen 10nm processors out to 2019. That's almost five years after Intel began pumping out 14nm chips in significant volumes. Likewise, Intel's 14nm node came three years after 22nm. Welcome to the post Moore's Law era, where faster computing for less money is no longer an automatic assumption.

That's a radical change that could threaten progress well beyond conventional computing. Advances in everything from AI and self-driving cars to medicine, biotechnology, and engineering are all predicated, at least in part, on the assumption that available computing power increases not only reliably but exponentially. It's the latter implication that has been most revolutionary. The exponential increase in computing power for nearly 50 years was unlike anything the world had seen before. And it begs the question of whether we'll ever see anything like it again.

The simple answer is almost certainly no. The regular cadence of Moore's Law as it pertains to integrated circuit engineering is over, and there's no obvious candidate to replace it. The good news, however, is that there is no shortage of candidate technologies that could provide anything from incremental improvements to revolutions so radical they could render the very notion of increasing compute power redundant. The future of computing will no longer be a model of serene progress; it will very likely be measured in paralyzing fits and dramatic starts.



Transistors built from carbon nanotubes could revolutionize computing efficiency.



No more Moore: Intel's 10nm node is heavily delayed.

THE SMARTPHONE in your pocket is more powerful than room-filling mainframe computers of yore. Not just a little more powerful, but many orders of magnitude more powerful. That, in the proverbial nutshell, is Moore's Law, and its implications are as incredible in raw technical terms as they have been transformational for human existence. Almost every aspect of modern life is dependent, ultimately, on computing.

But Moore's Law is history, and the future of computing, if it is to advance, must rely on some other paradigm. Want specifics? The Apple iPhone X is capable of around 200,000 times more floating point operations per second than the CDC 6600 of 1964, considered by most to be the world's first supercomputer, and roughly the size of a pickup truck. Admittedly, that number involves a not exactly like-for-like comparison, which would involve numerous qualifications under close inspection, yet it gives an accurate sense of the monumental and exponential implications of Moore's Law, and the astonishing progress in computing power over the last 50 years.

Moore's Law, of course, is the observation that transistor densities in integrated circuits double every two years. Put another way, it says computer chips either double in complexity or halve in cost—or some mix of the two—every couple of years. Or rather, they did from around 1975, when Gordon Moore (co-founder of Intel) adjusted his original observational time frame down from doubling every year to two years, until roughly five years ago, when it became apparent that development had slowed.

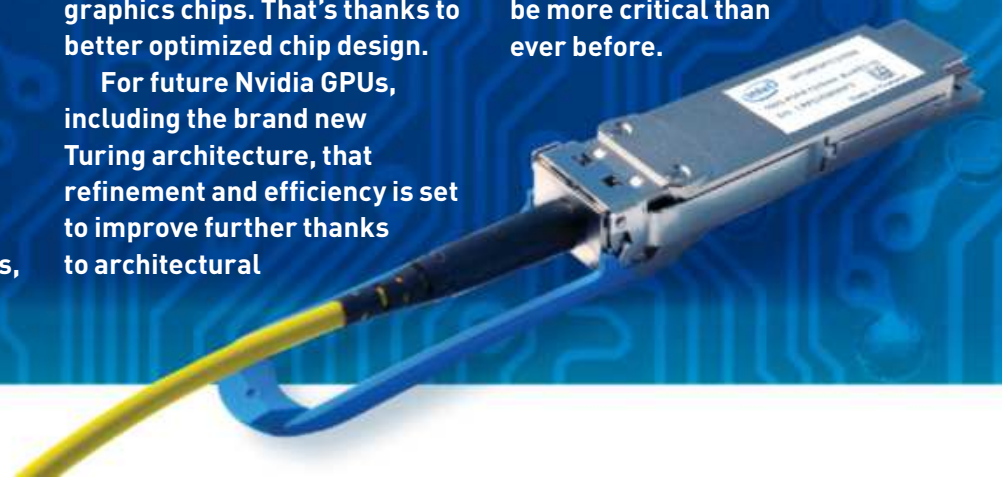
In 2015, Intel confirmed that the cadence of Moore's Law, as far as it was concerned, had slowed to 2.5 years with the transition from 22nm silicon chip production to 14nm. Fast-forward to the second half of 2018, and it's clear that Intel's step from 14nm to 10nm will require even longer—at least four years, probably getting on for five. The other

IF NOT QUANTUM COMPUTING, THEN WHAT?

Moore's Law is dead and quantum computing isn't coming to the rescue. Although, not any time soon. So, is there anything that can keep conventional computing moving forward? One promising technology is carbon nanotubes, one of those wonder technologies with seemingly infinite possible applications, from space elevators to solar cells. But how can they help computing? One of the key theoretical advantages of transistors built from carbon nanotubes could be much lower power consumption. That would allow for more powerful chips to operate within the limited energy budget of a device like a smartphone. Physically, it's easy to fit a desktop-class CPU die inside a smartphone. Powering it is the problem, and carbon nanotubes might solve it.

Optical interconnects both between and within chips are another big opportunity. Just as fiber-optic technology is boosting network speeds, including domestic Internet connections, building optical technology into computer chips could unlock a huge leap in bandwidth and energy efficiency. But of all the options, more efficient circuit design is likely to bring the most immediate benefits to compute power. Graphics chips are a handy yardstick, here. Already, Nvidia's GPUs are significantly more efficient in terms of overall graphics rendering performance per unit of die area than AMD's competing graphics chips. That's thanks to better optimized chip design.

For future Nvidia GPUs, including the brand new Turing architecture, that refinement and efficiency is set to improve further thanks to architectural tweaks that combine multiple small operations into a single larger operation. AMD is taking a similar approach with its Rapid Packed Math technology in the latest Vega GPUs, even if it remains behind for overall efficiency. With Moore's Law consigned to history, that kind of optimized chip design will be more critical than ever before.



D-Wave's 2X is the real, quantum-computing deal. But is it actually faster than conventional computers?

major players in chip production, including Taiwanese giant TSMC and South Korea's Samsung, have all suffered their own delays. The upshot of which is a consensus that the Moore's Law that pertained for around four decades is no longer.

Not that this is a surprise. The very nature of conventional integrated circuits guarantees the cadence of ever-shrinking transistors can't go on forever. The approach was sure to bang up against the limitations of matter eventually. Once you're making transistors from a handful of atoms, you've nowhere left to go.

The demise of Moore's Law isn't the only challenge facing conventional computing based on integrated circuits. As a happy corollary to increasing chip complexity, the shrinking proportions of transistors have been accompanied by an increase in the rate at which they can be switched on and off, and likewise a reduction in per-transistor power consumption. Combine the two, and you have both increased operating frequencies and reduced energy consumption per unit of compute power. That's pretty much a free lunch in computing terms, and it's been just as important for progressing overall performance as raw transistor density.

Unfortunately, improvements in operating frequency and energy efficiency have been even shorter lived than Moore's Law. In 2004, Intel hit 3.8GHz with its Pentium 4, and talk was of 10GHz computing. Nearly 15 years later, the sustainable clock speeds of its processors have improved by scarcely 1GHz. More recently, current leakage has become an increasing problem as transistors have grown smaller. Small enough, in fact, to find themselves hostage to quantum-level physical phenomena, such as quantum tunneling, which allows individual electrons to effectively leap across insulation barriers and thus "leak" energy and generate heat. The impact of that alongside the slowing of Moore's Law is profound. Where once it could be assumed that computer chips would get faster, more efficient, and cheaper, all at the same time, it's no longer possible to be confident about substantial gains by any of those metrics.

But is it that big a problem? After all, when it comes to desktop computing, many argue today's CPUs are already powerful enough. The extent to which PC processor performance has stagnated in recent years has also had at least as much to do with a lack of competition as the wheels coming off Moore's Law. Observe the impact AMD's Ryzen CPUs had on Intel. The latter stuck with four cores for mainstream desktop chips for around a decade, but a year after Ryzen appeared, Intel is launching eight-core models for its mainstream socket, has 18-core enthusiast chips already, and plans to up that to 28 cores in the near future.

Of course, all that involves a rather CPU-centric view of the universe. Other areas of computing remain predicated and reliant upon something at least close to Moore's Law rumbling on. True desktop computing power in a pocketable device isn't going to happen without substantial further progress, for instance. Ditto photorealistic computer graphics rendered in real time. However, it's the technologies that promise the most wide-ranging impact on human life, including AI, robotics, machine learning, and biotechnology, that have most to lose from the demise of Moore's Law. The scope and range of those endeavors will be curtailed if advances in compute power stall with the demise of Moore's Law.

But what can replace Moore's Law and drive computing power forward? The good news is that numerous candidates exist. Indeed, some industry observers think the death of Moore's Law is long overdue. In recent decades, the assumption that ever more conventional compute power will become available has arguably made

Today's smartphones offer orders of magnitude more compute power than the first room-filling supercomputers.

software developers lazy, and stymied research into alternative computing hardware paradigms. Why put in effort and money, when cheaper, faster computer chips are sure to solve the problem? With Moore's Law no longer, the impetus to develop alternatives is far more compelling.

The bad news: There's probably no single technology, idea, or approach that will directly replace Moore's Law and the conventional integrated circuit's incredible capacity for self improvement. If one thing seems fairly certain, the future progress of computing will be far less predictable, far less regular. Instead, progress is likely to come in sharp leaps after uneventful lulls.

However, if there is a single technology that offers the biggest theoretical upside, it's quantum computing. Its raw potential is mind-boggling. Long story short, it's possible to conceptualize a single quantum computer of remarkable simplicity and efficiency that's capable of not just matching the combined number-crunching muscle of all existing computers, but also executing essentially as many calculations at once as is practically useful. As Andy Rubin, of Android OS fame, said, "If you have computing that is as powerful as this could be, you might only need one [computer]."

What's more, quantum computing isn't a new idea, and its core premise is well established and understood. Yet it remains not just thoroughly exotic, but also controversial. The basics go something like this: Conventional computing operates in the binary realms of zeros and ones, aka bits. A transistor, the basic component in a classical computer, is thus either off or on, and nothing in between. Not so with quantum computing. Thanks to a property known as superposition, which prevails when dealing with very tiny atomic and sub-atomic particles, such as individual electrons, it's possible for a quantum computing bit to be not just on and off at the same time, but also a huge array of what you might call hybrid superpositions in between on and off. This is a qubit, and it's the basic building block of quantum computing.

AI, robots, or self-driving cars—the future depends on increasing compute power.

But the qubit's incredible, peculiar, and non-binary capacity isn't the whole story. It's the way qubits can interact with each other, thanks to another quantum property, that enables the real computational fireworks. Welcome to the weird and wonderful world of quantum entanglement. The concept is tricky for even highly qualified physicists to truly grasp, let alone us mere mortals, but it involves the notion that quantum mechanical properties, such as "spin," of two or more particles can be inextricably linked, even if separated by great distances. Change the spin of one particle, and others instantly react, regardless of the distance between them.

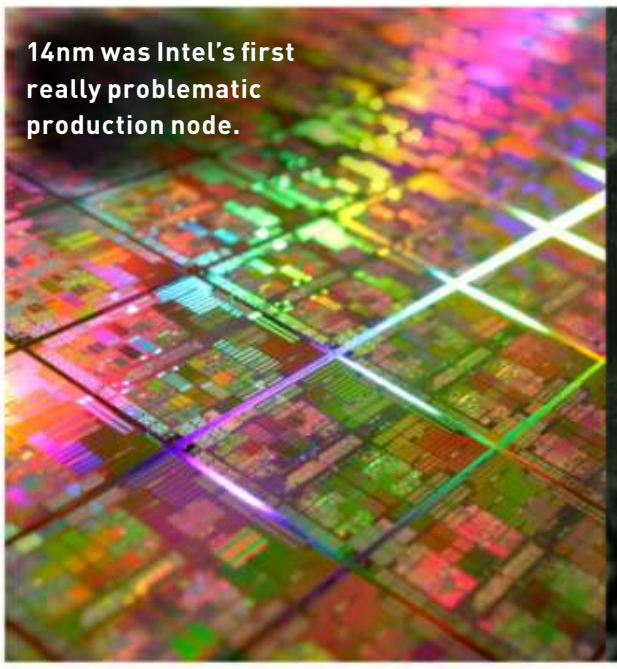
So, the trick to achieving really powerful quantum computing is to entangle multiple qubits. Quantum-mechanically link or entangle two qubits, and you can perform two calculations simultaneously. Link three qubits, and two to the power of three calculations—a total of eight—are possible. Link four, and you can perform 16 calculations simultaneously. Keep on going, and when you hit 300 entangled qubits, you can perform more calculations in parallel than there are atoms in the known universe. That's a lot of calculations—enough, in theory, to solve pretty much any

A LITERAL BRAIN BOX

Our brains are thought to be made of around 100 billion neurons, while the biggest computer chips top out at tens of billions of transistors. Meanwhile, each neuron can be connected to as many as 10,000 others, making for up to 1,000 trillion synaptic connections. By some metrics, the human brain is equivalent to a 1 trillion bit-per-second computer. Add to that the fact that the brain's peak power consumption is around 20 watts, and that makes the brain 10,000 times more efficient than the best integrated circuits.

Hold that thought while we consider another. Thanks to the increasingly power-hungry nature of computer chips, plus the rising cost of energy, it's more expensive to run a server for a few years than to buy it. Both in terms of increasing compute density and making it affordable to use, a big increase in efficiency would go a long way. The advanced micro-integration group at IBM's research lab in Zurich thinks the brain has the answer—or rather, the brain's fractally branching network of blood vessels makes for a very interesting model.

IBM is working on in-chip microfluidic channels that supply power and enable cooling. The idea functions like a flow battery, in which power is provided by two liquids that produce electricity when meeting on either side of a membrane. If the idea works, it'll be useful for 3D chips with multiple layers of integrated circuits.



14nm was Intel's first really problematic production node.

Try rendering *Crysis* on a CPU and you'll soon understand the benefits of single-purpose chips.

computational problem you can imagine. In practice? Not so much. At least, not yet. Earlier this year, physicists at the University of Science and Technology of China set a new record by achieving quantum entanglement with 18 photon-based qubits. But the rate of progress in achieving that number has been painstaking, and there are no signs of it taking off any time soon.

The problem is that the superpositions of qubits are very fragile. Tiny amounts of heat or magnetic interference can cause them, in effect, to collapse. Building a quantum computer is therefore far from easy. What begins with a relatively simple network of notional qubits quickly turns into a complex machine utilizing liquid-helium cooling down to a fraction of a degree above absolute zero, surrounded by heavy-duty magnetic shielding.

What's more, while commercial computers that exploit these quantum-level effects are available, they're not only limited physically by the need for intense cooling and shielding, but also limited in computational scope. The space inside a D-Wave 2X, one of the most commercially successful quantum computers available, is mostly given over to a liquid-helium refrigeration system capable of cooling its qubits down to just a fraction of a degree above absolute zero, while much of the remaining machine is made up of magnetic shielding that protects the qubits from fluctuations in Earth's magnetic field.

Despite all that technology and innovation, the D-Wave 2X's computational prowess is restricted to finding the lowest value of complicated functions. Granted, such calculations can be very useful in engineering, which is why Google, NASA, and Lockheed Martin are all reportedly D-Wave clients, but such a machine hardly makes for a promising candidate technology for future pocket computers. Indeed, for a while, there was some controversy whether D-Wave's computers really were quantum. That has now been firmly established in the affirmative, but debate remains whether D-Wave's technology is actually any faster than a conventional computer, even for the narrow computation of which it is capable. Some even view the whole field of quantum computing as an irrelevance, equivalent to the alchemist's quest to turn base metal into gold. Like quantum computing, that is indeed possible with today's technology. But not to a degree that it's actually useful.

So, in the short to medium term, quantum computing isn't going to step in where Moore's Law left off. Instead, what progress there is will come from a complex array of technologies, including not only quantum computing, but also biological analogs, a shift to cloud computing, more efficient circuit design, and dedicated chips built to do one thing really well (see boxouts). In the meantime, if there's a take-home lesson, it's that Moore's Law has run its course, and the next 50 years of computing will be very different from the last 50. Whether they'll be better or worse, only time will tell.

TODAY'S TECHNOLOGY, TOMORROW

While the temptation is to seek out radical new tech, a little lateral thinking can go a long way. Take cloud computing: Who needs faster phones when you can push the heavy lifting into the cloud? That's happening with services like Google Maps, where elements like routing are calculated on Google's servers. So, accelerating smartphone performance may be more dependent on improving network coverage and speeds than creating faster processors.

Dedicated circuits or chips are another example. Again, the idea is already in use. Imagine rendering a modern PC game purely on a CPU rather than a graphics chip, and you'll get an idea of how much more efficient a chip designed to do one thing well can be. If that approach can be combined with efforts to improve power consumption, it's possible to imagine PCs and even smartphones with numerous dedicated circuits or chips, each able to perform a single task far faster than any PC can today. If that's not possible, combine dedicated chips with the idea of pushing computing into the cloud, and you get the same result: more performance.

Of course, dedicated chips can be expensive to produce, which is why so-called programmable chips may have a bigger role to play. The idea behind such chips, known as field-programmable gate arrays (FPGA) is to create a chip that can be reconfigured on the fly. Made up of a matrix of configurable logic blocks connected via programmable interconnects, FPGAs are a sort of compromise between a general-purpose CPU and a fixed-function dedicated circuit.

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TECH PORN

512GB PNY Elite MicroSDXC Card CL 10 90MB/s

IN OUR INTER-CONNECTED AGE of technological marvels, the need for ever more storage has been one of the driving forces of an industry that never stops. From speed to latency, capacity, and form factors, it's something that we consumers constantly demand more of. Whether it's for phones, action cameras, flying 4K drones, or the latest Nintendo consoles, having access to more storage in ever smaller forms is imperative for keeping the experience both seamless and enjoyable.

It's staggering just how far we've come in the last few years alone. Step back just six years, and a 32GB microSD card would have set you back a serious bundle of cash, with the largest card limited to a total of 64GB. Fast-forward to 2018, and today we have access to arguably the largest microSD card on the market.

PNY's Elite microSDXC card packs a phenomenal 512GB of data into its minuscule form. At $360, it's hardly cheap, but for those looking for a one-card solution for all their data needs, it's perfect, and a prime example of how far we're pushing the latest technology. **–ZAK STOREY**

1 WARRANTY

512GB of pure performance lies at the heart of this SD card, and with a lifetime warranty covering it for the entirety of its on-sale duration, it's hard not to feel somewhat comforted by PNY's confidence in its product. Just keep that receipt.

2 APPLICATION

The big one: Where on earth would you use this? Well, from the get-go, there are two major uses: drones with built-in 4K cameras are the first no-brainer, and the second is Nintendo's Switch, which requires you to install the games direct to the SD card.

3 SPEED!

All four of the devices pictured above tout a 512GB capacity (or close enough)—that's half a terabyte of storage in their various form factors. Although the PNY SD card isn't as fast as its SSD counterparts, it's no slouch either, with speeds up to 90MB/s.

PERFECT VIDEO PLAYBACK

Neil Mohr takes you on a tour of video codecs for the ultimate theater-quality experience

WHY IS PLAYING VIDEO so complicated? Why does it play smoothly in one program, but not another? Why can you play it on this system, but not that one? Why does it stream OK, but not play locally? How can the video play, but not sound? How do you get subtitles to display? Why is the audio only in stereo, not surround? How come the colors are drab? All those questions have come from the mouths of people who had the audacity to try to play video.

Before you throw your PC out the window, we're offering you a masterclass in video playback. We'll explain the complexities of the Windows video pipeline (you'll see why things can become so difficult to diagnose), and discuss what software you need to get the best playback without the hassle, along with how to install and tweak it to perfection. Along the way, we'll see what hardware acceleration you can use, discuss the madness of the codec world, ensure sound isn't neglected, and cover 4K and HDR content, too.

You could very easily argue that local video playback has become redundant anyway, because streaming services have pushed content online, and that's where most people consume their entertainment. We're not going to argue with that, but if you still want to retain ownership of your paid-for movies and video, the only true way to do so is to have a local copy, otherwise you're really only borrowing it from a copyright holder under the guise of a license. We don't want to get bogged down in the philosophy of it all, so instead we're going to get bogged down in codecs—this should be fun....

THERE'S NO SUCH THING as a video player. Anything you think is a video player is actually just an elaborate black box, which happens to pull together a host of functions and features to make a moving image appear on your screen and audio pour out your speakers—all at the same time, incredibly, and in sync, down to the millisecond.

To understand how that black box works, we'll kick things off by taking a look at what goes into the video pipeline, from source to target. This will help us understand how the various elements plug together to decode, manipulate, and output our video and audio. We can then drill down into the individual blocks of the pipeline, and explain how to get the best from each part, and what's really needed.

The language used tends to be flexible. Microsoft DirectShow is the Windows system used to manage the flow of video data, and it refers to codecs as filters—largely because "codec" is a redundant term, as it means "(en)COderDECoder," and in this context, they're largely just decoder filters. We'll cover different terms as we come across them. Alongside that, read the "Just Get This..." box, and grab the suggested codec pack, plus Media Player Classic (MPC) from https://mpc-hc.org, to ensure we're all using the same software whenever we talk about settings and so on.

At the start is the source. That's usually a single video file, but even this is complicated. When dealing with a player such as MPC, you can specify separate video, audio, and subtitle files, and it combines them into a cohesive output. Video and audio tracks in MPC are loaded via "File → Open File," with subtitles loaded via "File → Subtitles," though subtitles contained within a file are controlled via the Demux and Subtitle filter, which we'll come to.

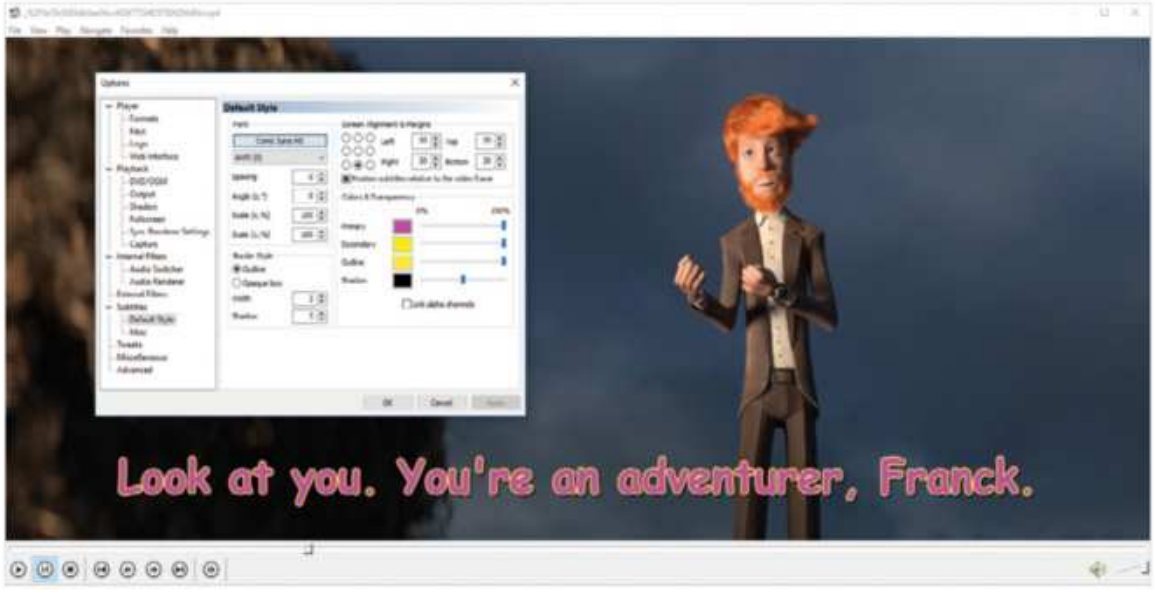
These days, a single video file is actually a container file format. Famously, there's AVI, MP4, and MKV. Ideally, a container format should offer a flexible way for a single file to contain multiple video, audio, and subtitle tracks. This largely explains the rise in popularity of MKV; it's open source, and supports almost all the features you could want, over and above AVI and MP4.

Compare the output of HDR content with and without processing.

Before we can do anything with the container file, we need a filter that can split the various parts into separate streams. This is called demultiplexing, or the Demux stage—a more layman's term is a splitter. If you're following our advice in the "Just Get This" box, it's the LAV Splitter—other splitters exist, such as the Haali Media Splitter. Settings (via the LAV Splitter preferences) can largely be set to default here, unless you happen not to be an English speaker, in which case you need to specify your preferred language for any audio and subtitles, so they can be picked up automatically if available.

SUBTITLES

We're going to tackle the subtitle stream first, as it's quite straightforward. Subtitles can be internal ones or external ones you've downloaded—for the latter, these are just text files with timestamps and translated lines. And, yes, you can create your own comedy ones if you like. K-Lite uses the long-standing DirectVobSub filter, which offers placement, typeface, aspect ratio, and loading controls. It looks for suitably named subtitle files in the same folder as the video file, in a "\subtitle" folder alongside the video file, or in a "c:\subtitles" folder. The file needs to be named exactly the same as the original video file, minus any extension, such as .mkv or .mp4. If you have issues with your vision, the placement and size settings can be very useful. For internal subtitles, use the MPC settings. Choose the required subtitles from "Play → Subtitles track." It has very similar controls under "View → Options → Subtitles settings."

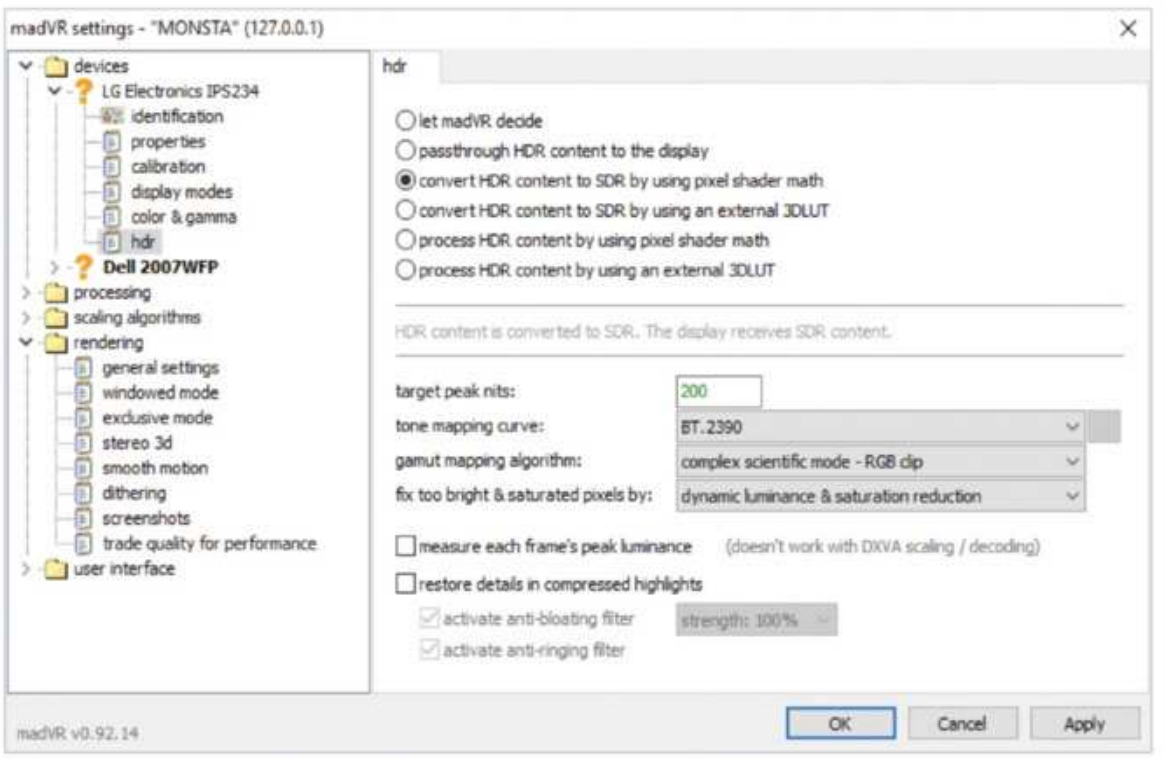


Custom Comic Sans subtitles is what the world was crying out for.

SOUND

Getting the correct surround sound from a Windows system to an external amp or device can be frustrating. This is largely down to the number of non-obvious drivers, different settings at each stage, physical outputs, and compatibility issues with DRM and modern digital audio formats.

The first step is to check Windows is outputting audio to the correct device. Right-click the notification "Speaker" icon, and select "Playback devices." Windows lists all the audio devices it thinks it can send audio to. Built-in audio typically offers separate analog and digital output. Suitable HDMI digital devices are also listed, while there may be additional devices with audio output, too. If there's no sound to be heard, it's likely the wrong device is selected here. You can also configure the basic setup, and tell Windows whether this is a stereo or surround system. However, systems running Realtek audio might have the



Mad, you say? The number of options for settings is completely bonkers.

COSMOS LAUNDROMAT - BLENDER FOUNDATION NETFLIX GETTY IMAGES

You need to select the MadVR renderer from within MPC.

JUST GET THIS...

Back in the day, we called it a "codec pack," an assortment of codecs bundled together so you could play pretty much any video you could throw at Windows Media Player. It was like the Wild West, with all manner of codec combos springing up. Thankfully, things have become a little more enlightened and professional.

If you want a simple answer to getting better video playback, we suggest you get the K-Lite Codec Pack Standard from http://codecguide.com. It's been around since 2003(ish), but recently underwent a modern dusting off.

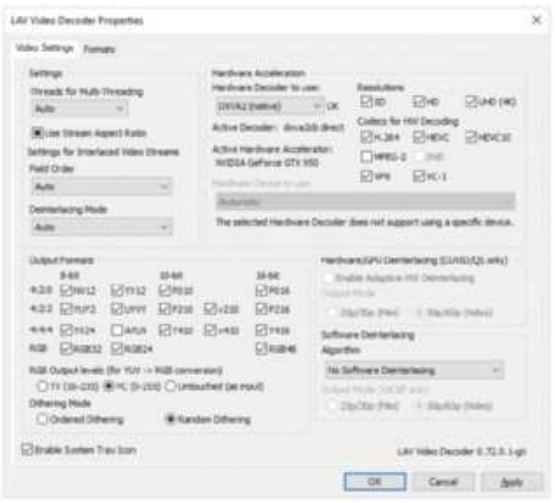
Inside the standard K-Lite pack, you'll find the cutting edge of open-source filter technologies: LAV video filter, LAV audio filter, and LAV splitter, alongside a number of other filters and tools. These first three handle all the various required filters to decode video and audio formats, plus container formats that hold them. You also get the widely used external subtitle filter, DirectVobSub, the popular Media Player Classic Home Cinema player, plus an external renderer, MadVR. There's a couple of useful tools for resetting settings and filter associations, too, in case things get messed up.

You can't install incompatible codecs/filters as such; DirectShow defaults to what it thinks is the best filter to use for the selected file type. What you can have are multiple codecs/filters installed that support the same format, and so are conflicting. For example, video-editing software installs its own codecs, but you might find these packs can cause issues or bizarre behavior.

company's proprietary preference system, where all this can be configured, too.

We're behind the times with audio, so we're still running a 5.1 surround system using stereo analog jacks—that's a jack per speaker pair, and one to handle both the sub and center speakers. The main reason is it forces decoding of any digital audio to the discrete surround channels. Otherwise, you need to pipe the raw digital signal down whatever digital connection you're using. The problem is, if your amp doesn't support that digital signal, you hear nothing, or the output device could fall back to stereo PCM audio, which won't make anyone happy.

As part of the K-Lite pack, LAV Audio is the main filter control for your audio. We'll look at using a digital audio device—think HDMI-connected device like a TV, or an AV amp via HDMI or optical—otherwise it's an analog connection. For digital movies, you'll want to enable bit-streaming—as long as your external device supports those formats—so the digital audio is streamed unmolested.



The main video filter controls add a little hardware acceleration here.

For analog targets, things aren't much more complex, but you'll want to specify the correct surround setup within the LAV Audio "Mixer" tab. Additionally, MPC has extended audio controls, if you need them, under "View → Options → Internal Filters → Audio Switcher." Normalization helps boost quiet dialog; there's also a custom channel mixer, so you can specify what channel goes to which speaker. When it comes to playing video, if there are multiple audio tracks—such as director's commentary, English audio, or description audio—select alternatives using "Play → Audio track."

VIDEO

Subtitles are reading right, audio sounds super, now we can turn to the video. LAV Video is the decode filter that delivers support for all the major formats, along with hardware acceleration support for Intel Quick Sync, Nvidia CUVID, and DXVA2 native/copy-back. If you don't have a GPU, Intel Quick Sync is better than nothing, but it can cause quality issues on older processors; Nvidia CUVID is somewhat outdated; while DXVA2 is the favored option.

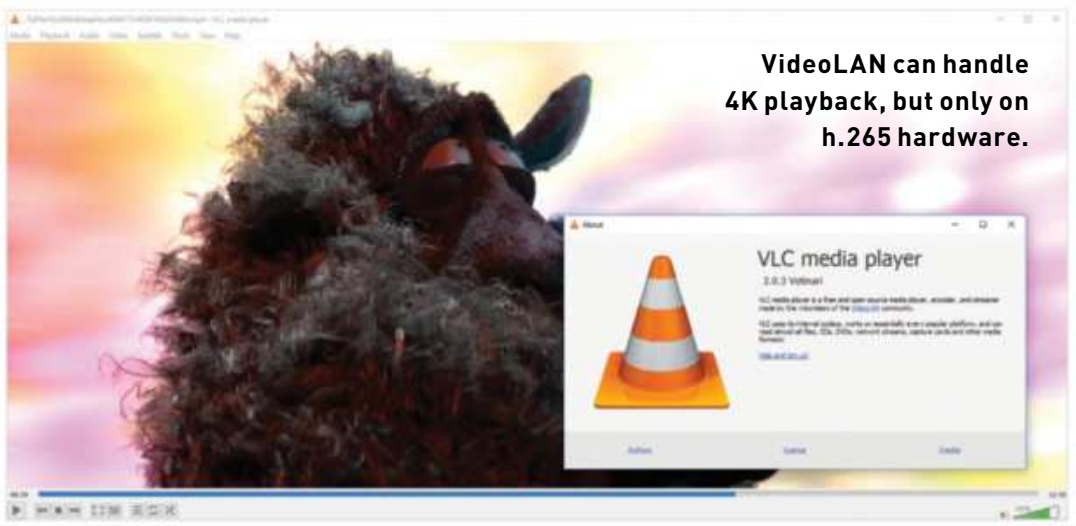
DXVA2 copy-back mode can enable higher quality video than native, as more filters can be applied, but it can increase the GPU load by three times. Native mode is faster, as the video data never leaves the GPU memory. You'll find the LAV Video settings tool in the K-Lite folder. Outside of hardware acceleration, you don't need to adjust anything, though we'd set "RGB Output Levels" to "PC (0 to 255)," otherwise you'll get pointless color space conversions.

We've largely been ignoring the need for a player, until now, but as we've come to actually playing video, it's worth hauling MPC into view. The open-source Media Player Classic has been the first choice of video player for years, but unfortunately, the 2017 release was the final one of the original maintainer. Thankfully, it seems some of the developers on http://forum.doom9.org are maintaining it with bug fixes.

MPC has loads of settings, but for video playback, we want "Options → Playback → Output"—the DirectShow Video pull-down enables you to select a renderer. The Enhanced Video Renderer (custom presenter) would do, but we're here to cover 4K HDR playback, which throws up issues that standard PC players can't handle. The current solution is to use a renderer called MadVR, selected from here, but it has its own setting tool in the K-Lite folder.

HDR HEADACHES

What's the issue with HDR, then? If you're viewing HDR content from a PC, there can



VideoLAN can handle 4K playback, but only on h.265 hardware.

THE WONDER THAT IS VIDEOLAN

Worthy of its own section is the VideoLan Client (www.videolan.org), aka VLC. It's famous for its ability to play anything you throw at it, even if the file is corrupt or partially recovered. The reasons for its amazing abilities are many: Firstly, it's open source, so it has been openly developed, and is available for free to all; secondly, it uses its own built-in codec systems, and it supports pretty much everything. VLC is based in France, which enables it to ignore most USA-based software patents that would prevent other programs from including certain codecs.

Version 3.0, released at the start of 2018, introduced a host of innovations that brought VLC right up to date. These included default hardware decoding to support 4K and 8K playback, HDR 12-bit color, the ability to Chromecast, HD audio pass-through, VR video support, 8+ audio channel support, cross-platform hardware acceleration, AV1 codec, and Java Blu-ray menus, among many other changes.

Largely, VLC "just works™," which means you can simply download it, then let it get on with playing your content. Our main issue is that it's a little ugly; the preferences are borderline indecipherable, not helped by its Linux roots, sometimes making options more complex. Another minus point is that it tends to not take advantage of GPU hardware as well as MPC does, so unless you have a processor that directly supports h.265 acceleration, it struggles to play 4K material.

"Typically, the display doesn't realize it's being fed HDR, but the PC can be equally clueless."

easily be a breakdown of communication between the display and the PC, even with an HDR setup. Typically, it's the display not realizing it's being fed an HDR signal, but the PC can be equally clueless about having an HDR-capable display attached. The solution is to process the HDR video file as it's being displayed to a standard color range. This isn't a simple process—every frame has to be processed, and when you're dealing with a 4K resolution, that requires some serious CPU/GPU grunt, which is exactly what MadVR delivers, along with a bunch of other abilities.

MadVR's full name is Madshi Video Renderer, and it's registered as a DirectShow Renderer Filter. As mentioned, you select it within MPC and other compatible players as the renderer. You'll find a MadVR setting tool within the K-Lite app folder, and when a video is playing, a control icon appears in the notification area, with shortcuts to the settings.

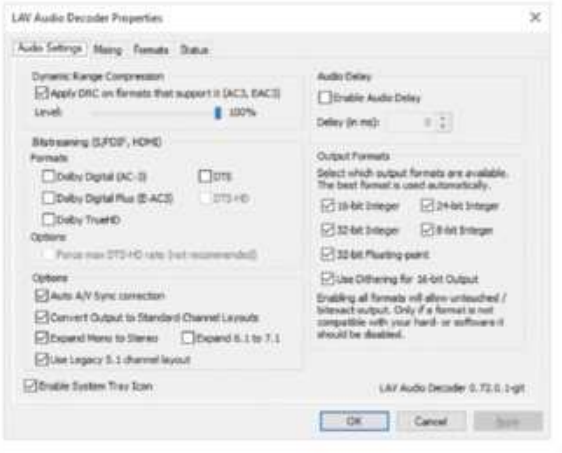
The short answer on how to get correct HDR playback using MadVR is to pop into "Settings → Devices → [your display] → Identification." Select the correct device type—it'll get a pretty icon as a reward. "Properties" are probably correct, unless you have a display with 10-bit color depth; "RGB levels" should be 0 to 255, as always. Jump to "HDR," as the rest should be fine with defaults. You can stick with "Let MadVR decide," and it'll do its best to try to detect what your GPU and display are capable of. But if colors are really muted, you need to manually select the correct mode. If you have an HDR-capable display and GPU, selecting "Passthrough HDR content to the display" is your best choice, because it allows the display to do the processing, and is your only option for Dolby Vision content.

"Convert HDR content to SDR using pixel shader math" is the mostly likely option to choose if you don't have an HDR-capable display or GPU. You can largely leave the settings as you find them; there is an option to adjust the maximum "nits," but 200 is sensible, even if a display supports brighter.

The final option we'll consider is "Process HDR content by using pixel shader math." This is the option if you have an HDR-capable display and GPU, but want to let MadVR do the HDR processing, which would be an odd thing to do, frankly. We're going to skip over the two LUT-based options, as we're not going into creating a custom 3D look-up table for your display.

At this point, you'd be fine to enjoy 4K HDR playback even on modest hardware sporting a suitable GPU. If you're interested in the other options, most are for scaling, smoothing, and dithering. Largely, we'd recommend any DXVA2 as the fastest option. "Smooth Motion" under "Rendering" is one option that can help eliminate judder due to mismatched refresh rates—the default "Only if there would be motion judder" is the best to choose.

We're standing on the shoulders of the giant brains over at http://forum.doom9.org, so if you're at all interested in video quality, encoding, playback, and codec technology in general, check it out for years' worth of archived posts and help.



Ensure you get decent sound levels and the correct channel mixing.

HOME THEATERS

We're closet fans of home theater setups. A quiet media center PC, powering a projector, and connected to a surround sound A/V amp makes for a formidable entertainment solution. For people from a PC background, though, the audio side of things can get neglected, but if you're entertaining the idea of a big screen, you're going to need a big soundscape to match.

We don't have space to explore all the options, but a good place to start is a suitable A/V amp with matching satellite surround speakers, plus a low-frequency effects subwoofer, if you're a fan of thumping bass. The latest marketing drive is Dolby Atmos, which adds vertical speakers to the mix, but even a basic 5/6/7.1 surround option is going to please your ears.

A potential issue for PC audio is the distinction between "generated" audio—from games, say—and pre-recorded DRM-protected audio, for a movie soundtrack. The later typically needs to be "passed through" to the A/V amp over a digital connection, else the DRM offers up the sound of silence. The flip issue when using a digital audio connection is that people only get stereo output for "normal" PC audio. The workaround is to use the audio jack's matrix output, and decode digital soundtracks to analog—yes, audiophiles, we went there.

Once you have a big screen, you'll want big sound to match, from something like this.

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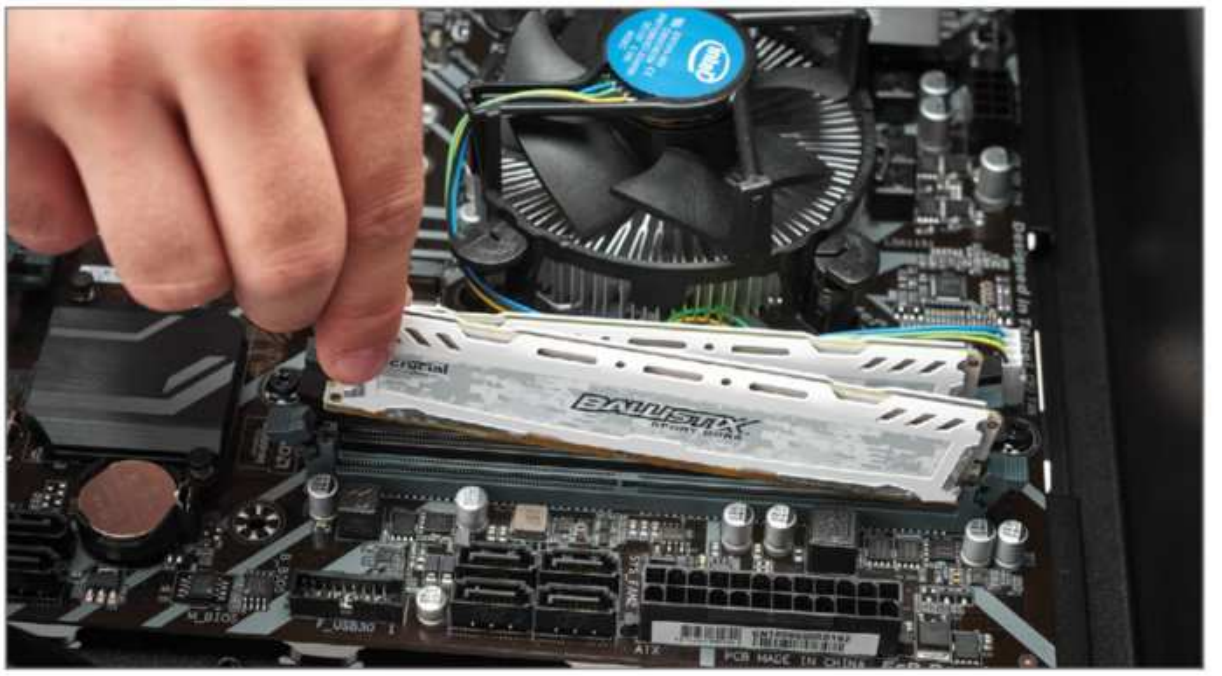
HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

TIP OF THE MONTH



MEMORY DIAGNOSTICS

Trouble booting? Struggling with a black screen? BIOS debug codes not making sense? We'll put money on your problem being memory-based; 95 percent of the time when diagnosing mobos, we pull the memory first. Try booting off one stick, use alternative slots, try multiple sticks, or even remove the CPU cooler and reseat the CPU. Nine times out of ten, it fixes the issue—if not, your system might be pushing up daisies.

ZAK STOREY
DEPUTY EDITOR

FRANKENSTEIN'S MOTHERBOARD

Unsurprisingly, given my reviewing responsibilities, I've killed my fair share of mobos. Recently, though, I destroyed one that was more frustrating than usual: the one in my home rig. I was running a Ryzen 7 1700 alongside an Aorus X370 Gaming K7 in a system I'd quickly thrown together last summer, before a few of my buddies came over for our "night-before-camping" gaming sesh.

The Gigabyte board decided it no longer wanted its second BIOS (I'd killed the first playing *WoW),* and was stuck on the black screen of death, with the BIOS debug codes cycling manically around. After trying the usual mobo diagnostic routine (reseat everything, and try individual memory sticks), time of death was confirmed.

Ironically, this was the night before this year's annual camping trip, so it meant another swap out, to ensure we had a rig to play local multiplayer games. Onward and upward: MSI X470 Gaming M7 AC and Ryzen 7 2700X.

The problem is, this stitched-together monster is getting more and more troublesome. I should have done a complete format and reinstall, as the conflicts between programs were clear, from random game crashes to all sorts of niggles and bugs. It took a complete driver and chipset reinstall to get it stable, and I'm itching to get a new, clean build at this point. She ain't holding up no more. **–ZAK STOREY**

MAKE – USE – CREATE

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Create a digital assistant using a Raspberry Pi

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Add movement to your photos with Photoshop timelines

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How a downgrade strangely transformed into an upgrade...

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IFIXIT presents:

AUTOPSY

THIS MONTH WE DISSECT...

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iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products.
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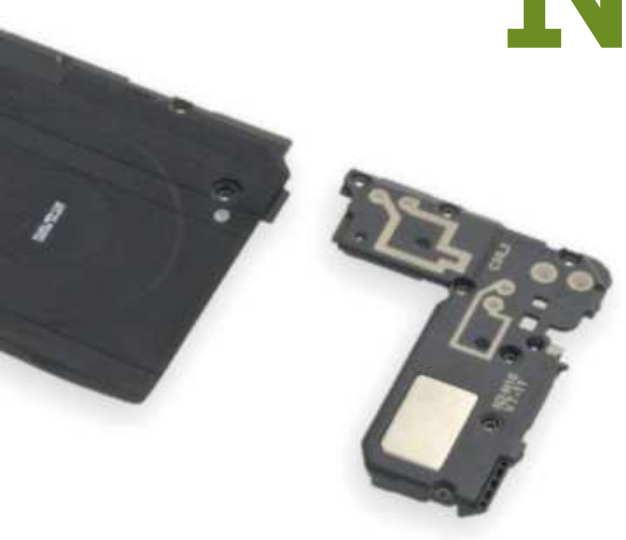
Samsung Galaxy Note9



There's not a lot of wiggle room from the fingerprint sensor cable.

The USB-C daughterboard should be easy to replace if damaged.

BACKGROUND

Samsung is at it again with the Galaxy Note9, right on schedule. Amid a brutal anti-Apple ad campaign, it's hoping a cool new S Pen is enough to carry the day. Could there be more waiting for us under the hood? We'll tear down to find out!

MAJOR TECH SPECS

- Notchless edge-to-edge 6.4-inch Super AMOLED display with 2960×1440 resolution (516 ppi)
- Octa-core Qualcomm Snapdragon 845, with 6GB/8GB RAM
- 4,000mAh battery
- 12MP OIS dual rear camera, with dual-aperture f/1.5–f/2.4 wide-angle and f/2.4 telephoto modules, plus 8MP selfie cam
- 128GB/512GB storage, extra 512GB available via microSD
- S Pen stylus with Bluetooth connectivity
- IP68 dust and water resistance rating

KEY FINDINGS

- The Note9 looks very similar to the Note8—and in principle, we're fine with that. So, what is new? Well, it's very slightly wider and shorter than the Note8, with an extra 0.1 inches of display, and it's a hair thicker at 8.8mm versus 8.6mm. In an increasingly rare (but welcome) move, Samsung has kept the analog headphone jack. Another subtle (but good) change: The fingerprint sensor has packed its things and moved to a happier location, south of the rear camera.
- We'd like to hit the ground running, but the back panel adhesive is pretty OP. Our usual strategy of heat, suction, and careful slicing does the trick eventually. The new fingerprint sensor location is welcome—the flex cable is less vulnerable to accidental slicing and dicing. That said, it's still too short.
- The battery's still glued down in a miserable sticky well—but the Note8 didn't blow up, so the design is justified, eh Samsung? The battery weighs in at a ludicrous 15.4Wh, eschewing the cautious 12.71Wh Note8 battery, and eclipsing the Note7 (13.48Wh) and iPhone X (a "mere" 10.35Wh).
- The motherboard has absorbed yesteryear's daughterboard, leaving a modular USB-C port (with hanger-on mic) ripe for the picking. Samsung continues to provide sanctuary for the now endangered headphone jack, while saddling it with a super-thin spring-contact-connected cable. The heat pipe has significantly more surface area than prior generations.
- We couldn't find a non-destructive way to crack open the S Pen, so we swapped in the ultrasonic blaster cutter! We conjecture that the S Pen charges via the sensing coils near its tip. We found a gray pad near where the coils reside when the stylus is stowed—possibly an inductive charging pad.
- The Note9 isn't a radical redesign, but it's fresh enough to keep our teardown engineers happy. The Note line tends to evolve slowly—bigger motherboard, a different pen, nothing major—except for a battery that exploded in size.
- Repairability score: 4 out of 10 (10 is easiest to repair). This Note's components are more modular than ever, thanks to subtle changes to the USB-C hardware, headphone jack, and the S Pen dock's flex cable. The only screws are standard Phillips ones. You can replace the battery if determined—two stubborn glue barriers make it difficult. To service any component you must painstakingly unglue (then reglue) the glass rear panel. Display repairs require replacing the entire chassis or tediously separating the gluey cracked glass.

Create Your Own Digital Assistant

YOU'LL NEED THIS

RASPBERRY PI
The credit-card-sized computer costs as little as $35.

IN THIS TUTORIAL, WE'RE LOOKING at what you need to make your own voice control software for your Raspberry Pi projects. If you want a virtual assistant, one project is the Jasper system (http://jasperproject.github.io). The documentation on the main Jasper website has a description of the hardware to attach to your Raspberry Pi, along with a full set of instructions for installation and configuration. There's a set of standard modules included to allow interaction with various services—use the time, Gmail, or even the joke module—and there are also third-party modules for you to access. There is even a developer API and documentation to help you add your own functionality to Jasper. **–JOEY BERNARD**

1 VOICE CONTROL

Everyone who has watched the *Iron Man* movies has probably dreamed of having their own artificially intelligent computer system to do their bidding. While J.A.R.V.I.S. has massive amounts of computing power behind him, you can construct the front end with very modest resources. With a Raspberry Pi and the Python programing language, you can build your own personal digital assistant that can be used as a front end to whatever massive supercomputing resources you use in your day-to-day life as a playboy philanthropist genius. Over the next few pages, we'll go over the basics that you need to know, so that by the end of this tutorial, you should be able to build your own rudimentary, customized agent.

›› The first step to interacting with the humans around us is to listen for verbal commands, so that we know what we need to process. You have several options available to handle this task. To keep things simple, we are dealing only with devices that are plugged into one of your Raspberry Pi's USB ports. With that stipulation, you can talk directly with the USB device at the lowest level. This might be necessary if you are trying to use something that is rather unusual to do the listening, but you would probably be better off using something a bit more commonplace. In this case, you can use the Python module PyAudio. PyAudio provides a Python wrapper around the low-level cross-platform library PortAudio. Assuming you are using something like Raspbian for your Linux distribution, you can easily install the required software with the command:

```
sudo apt-get install python-pyaudio
```

›› If you need the latest version, you can always grab and build it from source. PyAudio provides the functionality to read in audio data from a microphone, along with the ability to play audio data out to headphones or speakers. So, we're using it as our main form of interaction with the computer.

›› The first step is to be able to read in some audio commands from the humans who happen to be nearby. You need to import the PyAudio module before you can start interacting with the microphone. The way PyAudio works is similar to working with files, so it should seem familiar to most programers. You start by creating a new PyAudio object with the statement `p = pyaudio.PyAudio()`. You can then open an input stream with the function `p.open(...)`, with several parameters. You can set the data format for the recording; in the example code, we used `format=pyaudio.paInt16`. You can set the rate in hertz for sampling. For example, we are using `rate=44100`, which is the standard 44.1KHz sampling rate. You also need to say how big a buffer to use for the recording—we used `frames_per_buffer=1024`. Because we want to record, you need to use `input=true`. The last parameter is to select the number of channels to record on—in this case, we're using `channels=2`. Now that the stream has been opened, you can start to read from it. You need to read the audio data in using the same chunk size that you used when you created the stream—it looks like `stream.read(1024)`. You can then simply loop and read until you are done. There are then two commands to shut down the input stream. You need to call `stream.stop_stream()` and then `stream.close()`. If you are completely done, you can now call `p.terminate()` to shut down the connection to the audio devices on your Raspberry Pi.

›› The next step is to be able to send audio output so that J.A.R.V.I.S. can talk to you as well. For this, you can use PyAudio, so we don't have to look at another Python module. To make things simple, let's say that you have a WAV file that you want to play. You can use the "wave" Python module to load it. Once again, you create a PyAudio object, and open a stream. The parameter "output" should be set to true. The format, the number of channels, and the rate is all information that is derived from the audio data stored in your WAV file. To actually hear the audio, you can simply loop through, reading one chunk of data from the WAV file at a time, and immediately writing out to the PyAudio stream. Once you're done, you can stop the stream and close it, as you did above.

›› In both of the above cases, the functions block when you call them until they have completed. So, what are the options if you want to be able to do processing while you are either recording audio or outputting audio? There are non-blocking versions that take a callback function as an extra parameter, called `stream_callback`. This callback function takes four parameters, named `in_data`, `frame_count`, `time_info`, and `status`. The `in_data` parameter contains the recorded audio if input is true. The callback function needs to return a tuple with the values `out_data` and `flag` — `out_data` contains the data to be outputted if output is true in the call to the function open. If the input is true instead, then `out_data` should be equal to None. The flag can be any of `paContinue`, `paComplete`, or `paAbort` —with obvious meanings. One thing to be aware of is that you cannot call, read, or write functions when you wish to use a callback function. Once the stream is opened, you simply call the function `stream.start_stream()`. This starts a separate thread to handle this stream processing. You can use `stream.is_active()` to check on the current

status. Once the stream processing is done, you can call `stream.stop_stream()` to stop the secondary thread.

2 OFFLOAD TASKS

You can offload the audio data processing to Google, accessing the API directly over HTTP by posting your audio data to the appropriate URL. First, install the Python module SpeechRecognition:

```
pip install SpeechRecognition
```

» Now create an instance of the Recognizer object. A Helper object, called WavFile, takes an audio file and prepares it for use by the Google API, then processes it with the `record()` function, and hands this processed audio to the function `recognize()`. When it returns, you get a list of pairs of possible texts, along with a percentage confidence level for each possible text decoding. Be aware that this module uses an unofficial API key to do its decoding, so for anything more than small personal testing, you should request your own API key.

» We've seen how we can make our Raspberry Pi listen to the world around it, now we need to try to make sense of what it might have just heard. In general, this is called speech recognition, and it is a very large and active area of research. Every major smartphone operating system has applications trying to take advantage of this mode of human interaction. There are also several different Python modules available that can perform this speech-to-text (STT) translation step. In this part of our project, we're looking at using Pocket Sphinx to do all the heavy lifting. Sphinx was developed by Carnegie Mellon University, and is licensed under a BSD license, so you are free to add any extra functionality that you may need for specific tasks. Because of the activity in this field, it is well worth your time to keep track of all the updates and performance improvements.

» While you can download the source code for all of these modules, and build it all from scratch, we're assuming that you are using one of the Debian-based distributions, such as Raspbian. For these, you can simply use the following to get all of the required files for the engine:

```
sudo apt-get install python-pocketsphinx
```

» You also need audio model files and language model files in order to get a translation in your language of choice. To get the files needed for English, you can install the packages:

```
sudo apt-get install pocketsphinx-hmm-wsj1 pocketsphinx-lm-wsj
```

» You may need to go outside the regular package management system if you want to process other languages. Then you can simply start writing and using your code straight away. To begin using these modules, you need to import both Pocket Sphinx and Sphinx Base with the following commands:

```
import pocketphinx as ps
```

VOICE CONTROL: FULL CODE LISTING

```
# You need to import the PyAudio module
import pyaudio

# First, we will listen
# We need to set some parameters
# Buffer chunk size in bytes
CHUNK = 1024
# The audio format
FORMAT = pyaudio.paInt16
# The number of channels to record on
CHANNELS = 2
# The sample rate, 44.1KHz
RATE = 44100
# The number of seconds to record for
RECORD_SECS = 5

# Next, we create a PyAudio object
p = pyaudio.PyAudio()

# We need a stream to record from
stream = p.open(format=FORMAT, channels=CHANNELS,
rate=RATE, input=TRUE, frames_per_buffer=CHUNK)

# We can now record into a temporary buffer
frames = []
for i in range(0, int(RATE / CHUNK * RECORD_SECS)):
  data = stream.read(CHUNK)
  frames.append(data)

# We can now shut everything down
stream.stop_stream()
stream.close()
p.terminate()

# If we want to play a wave file, we need the wave module
import wave

# We can open it, give a filename
wf = wave.open("filename.wav", "rb")

# We need a new PyAudio object
p = pyaudio.PyAudio()

# We open a stream, using the settings from the wave file
stream = p.open(format=p.get_format_from_width(wf.
getsampwidth()),channels=wf.getnchannels(), rate=wf.
getframerate(),output=True)

# We can now read from the file and play it out
data = wf.readframes(CHUNK)
while data != '':
    stream.write(data)
    data = wf.readframes(CHUNK)

# Don't forget to shut everything down again
stream.stop_stream()
stream.close()
p.terminate()
```

OFFLOAD TASKS: FULL CODE LISTING

```
# You first need to import the required modules
import pocketsphinx as ps
import sphinxbase

# Next, you need to create a Decoder object
hmmd = '/usr/share/pocketsphinx/model/hmm/wsj1'
lmd = '/usr/share/pocketsphinx/lm/wsj/wlist5o.3e-7.vp.tg.lm.DMP'
dictd = '/usr/share/pocketsphinx/lm/wsj/wlist5o.dic'
d = ps.Decoder(hmm=hmmd, lm=lmd, dict=dictd)

# You need to jump over the header information in your WAV file
wavFile = file('my_file.wav', 'rb')
wavFile.seek(44)

# Now you can decode the audio
d.decode_raw(wavFile)
results = d.get_hyp()

# The most likely guess is the first one
decoded_speech = results[0]
print "I said ", decoded_speech[0], " with a confidence of ", decoded_speech[1]

# To do live decoding, you need the PyAudio module
import pyaudio
p = pyaudio.PyAudio()

# You can now open an input stream
in_stream = p.open(format=pyaudio.paInt16, channels=1, rate=16000,input=True, frames_per_buffer=1024)
in_stream.start_stream()

# Now you can start decoding
d.start_utt()
while True:
  buf = in_stream.read(1024)
  d.process_raw(buf, False, False)
  results = d.get_hyp()
# Here you would do something based on the decoded speech
# When you are done, you can shut everything down
  break
d.end_utt()
```

`import sphinxbase`

These modules are actually Python wrappers around the C code that handles the actual computational work of translating sounds to text. The most basic workflow involves instantiating a Decoder object from the Pocket Sphinx module. The Decoder object takes several input parameters to define the language files it is allowed to use. These include `hmm`, `lm`, and `dict`. If you use the above packages used to handle English, the files you need are in the directories "/usr/share/pocketsphinx/model/hmm/wsj1" and "/usr/share/pocketsphinx/model/lm/wsj." If you don't set these parameters, it tries to use sensible defaults, which usually work fine for English language speech. This newly created Decoder object can now be given WAV files with data to process. If you remember, we previously saved the recorded speech as a WAV file. In order to have this audio recorded in the correct format, you need to edit the code from the first step, and ensure that you are recording in mono (using one channel, for example), and recording at 16kHz with 16-bit quality. To read it properly, you can use a file object, and load it as a binary file with read permissions. WAV files have a small piece of header data at the beginning of the file that you need to jump over. This is done by using the `seek` function to jump over the first 44 bytes. Now that the file pointer is in the correct position, you can hand the file object to the Decoder object's `decode_raw()` function. It then goes off and does a bunch of data crunching to try to figure out what was said. To get the results, you use the `get_hyp()` function call. You get a list with three elements from this function: a string containing the best guess at the spoken text, a string containing the utterance ID, and a number containing the score for this guess.

» So far, we've looked at how to use the generic language and audio models for a particular language. But Pocket Sphinx is a research-level language system, so it has tools available to enable you to build your own models [**Image A**]. In this way, you can train your code to understand your particular voice, with all its peculiarities and accents. This is a long process, so most people aren't interested in doing something so intensive. However, if you are interested, there is information available at the main website (http://cmusphinx.sourceforge.net). You can also define your own models and grammars to tell Pocket Sphinx how to interpret the audio that it's processing. Once again, effectively carrying out these tasks requires more in-depth reading on your part.

» If you want to process audio more directly, you can tell Pocket Sphinx to start processing with the function `start_utt()`. You can then start reading audio from your microphone. You need to read in appropriate sized blocks of data before handing it to Pocket Sphinx—specifically to the function `process_raw()`—and you still need to use the function `get_hyp()` to actually get the translated text. Also, because your code can't know when someone has finished a complete utterance, you need to do this from within a loop. On each pass of the loop, read another chunk of audio, and feed it in to Pocket Sphinx. You then need to call `get_hyp()` again to see if you can get anything intelligible from the data. When you are done doing this real-time processing, you can use the function `end_utt()`.

3 SOCIAL MEDIA

You may want your system to check your social media accounts on the Internet. There are several Python modules available to handle this. Let's say that you want to be able to check your Facebook account. Install the following Python module:

`sudo apt-get install python-facebook`

» You can then use `import facebook` to get access to the Facebook API. If you're a Twitter user, you can install the python-twitter Debian package to use the Twitter API. Email is easier, as long as your email provider offers IMAP or POP access. You can then import emails and get voice control to read unread emails out to you. For the Google fans, Google has a Python module that provides access to the APIs for almost everything available; work with your calendar, email, or fitness data.

» You should now have a string containing the text that was spoken to your Raspberry Pi. But you need to figure out what command this maps to. One method is to do a search for keywords. If you have a list of keywords available, you can loop through them, and search the heard string to see whether any one of those keywords exist within it as a substring. Then you can execute the associated task with that keyword. However, this method only finds the first match. What happens if your user accidentally includes a keyword in their spoken command before the actual command word? This is the auditory equivalent to having fat fingers and mistyping a command on the keyboard. Being able to deal with these errors gracefully is an ongoing area of research. Maybe you can create a new algorithm to handle these situations—let us know if you come up with something.

» Let's say that you have a series of Python scripts that contain the various tasks you want your system to be able to tackle. You need a way to have your system be able to run these scripts when called upon. The most direct way to run a script is to use `execfile`. Say you have a script called "do_task.py" that contains Python code that you want to run when a command is given—you can run it with:

```
execfile("do_task.py")
```

» Using this form, you can add command-line options to the string being handed in. This looks in the current directory for the script of that file name, and runs it in the current execution context of your main program. If you need to rerun this code multiple times, call `execfile` each time you do. If you don't need the script to run within the same context, use the Subprocess module. You can import it with:

```
import subprocess
```

» You can then execute the script like so:

```
subprocess.call("do_task.py")
```

» This forks off a subprocess of the main Python interpreter, and runs the script there. If your script needs to interact with the main program, this is probably not the method to use. Collecting output from a call to "do_task.py" with Subprocess isn't straightforward, so another way of achieving the same thing is to use the `import` statement. It also runs the code in your script at the point the `import` statement is called. If your script only contains executable Python statements, these get run at the point of importation. In order to rerun this code, you need to use the `reload` command. The `reload` command doesn't exist in version three of Python—so, if you're using that particular Python version, a better option is to encapsulate the code contained in the script within a function. You can then import the script at the beginning of your main program, and simply call the relevant function at the correct time. This is a much more Pythonic method to use. If you have the following contents for do_task.py...

```
def do_func():
  do_task1()
  do_task2()
```

...you can use it with the following code within your main program:

```
import do_task
....
....
do_task.do_func()
....
```

» An even more Pythonic method is to use classes and objects. You can write a script that defines a class that contains methods for you to call when you need it.

» What are the options if you want to do something that isn't achievable with a Python script? In these cases, you need to be able to run arbitrary programs on the host system. The host system in this case is your Raspberry Pi. As a toy example, let's say you need to download some emails using the Fetchmail program. You can do this in a couple of different ways. The older method is to use the `os.system()` command where you hand in a string. In our example, this would look something like the following:

```
os.system("/usr/bin/fetchmail")
```

» You need to explicitly use `os.wait()` to be told exactly when the task has finished. This method is now being replaced by the newer Subprocess module. It gives you more control over how the task gets run and how you can interact with it. A simple equivalent to the above command would look like this:

```
subprocess.call("/usr/bin/fetchmail")
```

» It waits until the called program has finished and then returns the return code to your main Python process. But what if your external program needs to feed in results to your main program? In this case, you can use the command `subprocess.check_output()`. This is essentially the same as `subprocess.call()`, except that when it finishes, anything that is written out by the external program to stdout gets handed in as a string object. If you also need information written out on stderr, you can add the parameter `stderr=subprocess.STDOUT` to your call to `subprocess.check_output`.

» You should now have enough of the bare bones to be able to build your own version of the J.A.R.V.I.S. system. You will be able to fine-tune it to do basically anything that you command it to do. So, go forth and order your machines around, and have them actually listen to what you are saying for once.

SOCIAL MEDIA: FULL CODE LISTING

```
do_task.py
----------
def do_func():
  print "Hello World"

main_program.py
---------------

#You can import your own module to do tasks and commands
import do_task

# You can then go ahead and run any included functions
do_task.do_func()

# You can run system programs directly
import os

# The exit code from your program is in the variable returncode
returncode = os.system("/usr/bin/fetchmail")

# The subprocess module is a better choice
import subprocess

# You can duplicate the above with
returncode = subprocess.call("/usr/bin/fetchmail")

# If you want to get the output, too, you can use
returned_data = subprocess.check_output("/usr/bin/fetchmail")
```

Calibrate Your Computer Monitor

YOU'LL NEED THIS

SCREEN CALIBRATION DEVICE
The Datacolor Spyder 5 Express costs around $130.

ANYONE WHO SITS LOOKING AT A MONITOR ALL DAY, then perhaps goes home and looks at another, will know one thing about them: Two screens are rarely the same.

One may be brighter than the other, or have more yellow in its output, and while these discrepancies may be forgivable in a simple office machine, if you have a twin-screen setup, you'll want the displays to output the same brightness and color temperature. This is especially true if you've mixed and matched your monitors, because the Asus 4K model on the right you got for gaming may not match the BenQ 1080p screen on the left you use for Google Docs and email.

The color output of your screen becomes an issue if you're printing, too. While no amount of ink on paper, which is dependant on the light it reflects, can reproduce the color intensity of an image backlit by thousands of tiny glowing cells, a calibrated screen can at least ensure you don't end up with a print that's wildly darker or lighter than you expected—especially annoying if you've ordered hundreds from an online service.

We're using the lowest-cost Spyder calibration device here, but if you want more control over your screen, more expensive models are available. You can also use Windows 10's built-in controls, and we'll go over those, too. –IAN EVENDEN

A

1 TURN ON YOUR SCREEN

This may sound obvious, but it's a good idea to do something else for half an hour before beginning the calibration process. This allows the screen to warm up [**Image A**], and display its true colors—it may be darker and less vibrant when it's just switched on. You'll also want to use each screen's on-screen display to reset its brightness and contrast to neutral levels, as if it had just come out of the box. This is also a good time to dig out the exact make and model of your screen—you might need it later.

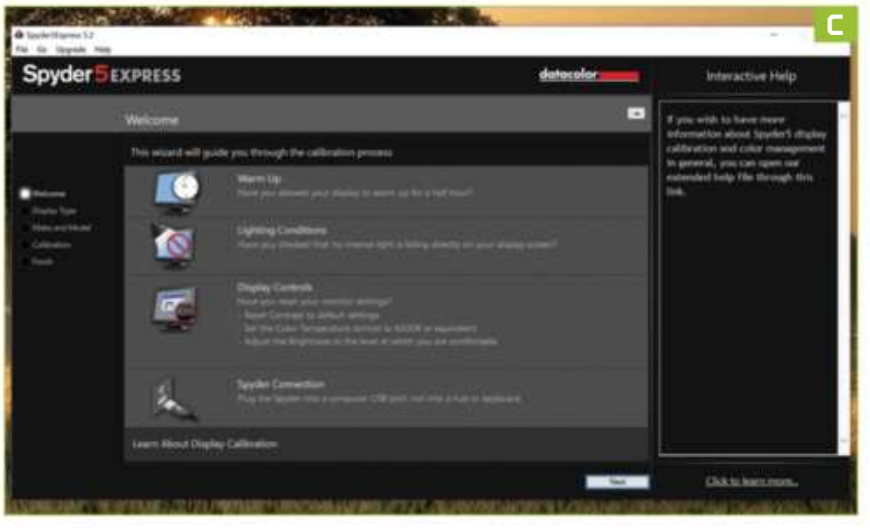
2 ENTER THE SPYDER

If you're using a calibration device, now's the time to take it out of its box. We're using a Datacolor Spyder 5 Express [**Image B**], but other brands are available. It's an entry-level device, and will calibrate your screen to an industry standard color reference, though it neglects to say what that standard is. This means you don't get a choice of calibrations based on what looks best for you—Spyder knows best, and you accept what it gives you. Of course, this doesn't mean you can't nudge the brightness up a bit once it's finished, but this may come back to bite you when you start printing. If you choose to upgrade your Spyder software to a more expensive version, you get a lot more choice about how the calibration is applied, but we're using the entry-level version here.

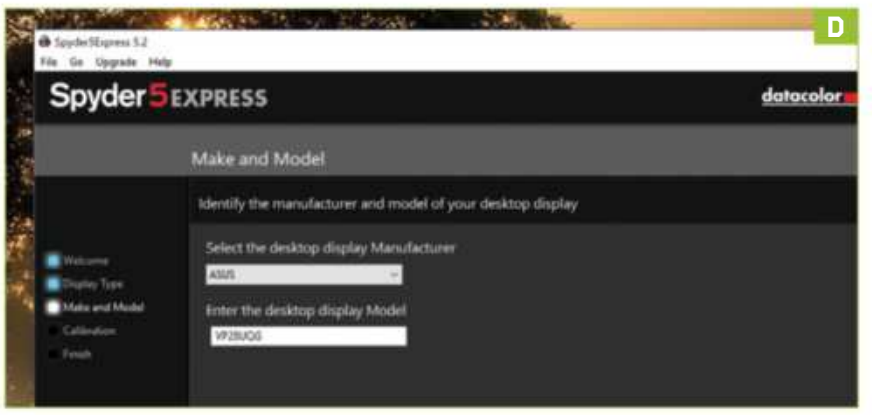
3 TAKE OFF THE LENS CAP

There's a lens cap on the Spyder device. We failed to remove it the first time, and wondered why it didn't work. Under the cap is something that looks rather like a plastic honeycomb, with an ambient lighting sensor on

B



C


Spyder5EXPRESS
datacolor
Make and Model
Identify the manufacturer and model of your desktop display
Select the desktop display Manufacturer
Enter the desktop display Model
D

the other side. Install the software that comes with the device, and make sure there's a spare USB port in easy reach of your screen. The documentation recommends not using a hub, but we ran it through a powered USB 3 hub with no apparent problems. Run the Spyder software, take in what it says about light falling on your screen and resetting the color temperature, plug in the colorimeter, then hit "Next" [**Image C**]. If multiple screens are detected, you're asked which monitor you want to calibrate (it only recognized one of ours, cataloguing the other as "Generic PnP"), then hit "Next" again. It's a wizard-based process, so is easy to follow.

4 WHAT EXACTLY IS IT?

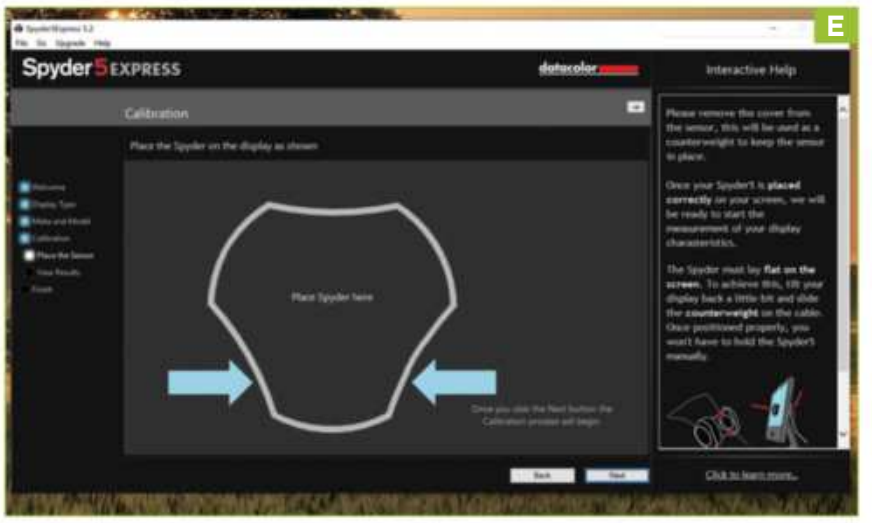
If your monitor hasn't been recognized correctly, you need to feed this into the software. First, tell it whether you're calibrating a desktop or laptop, then paste the make and model into the next screen [**Image D**]. Hit "Next."

5 BALANCING ACT

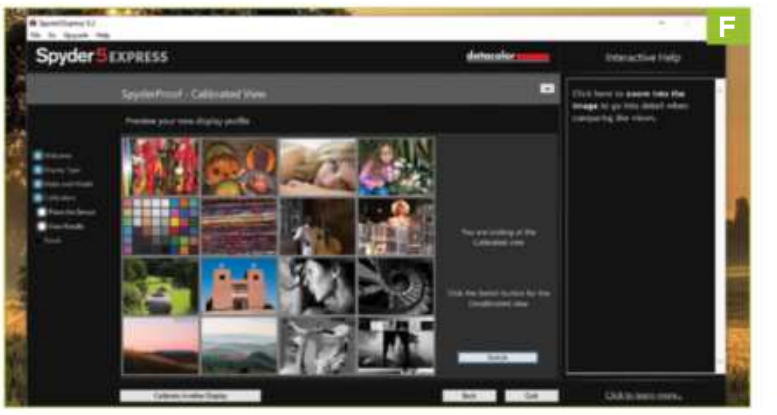
This is the point at which you need to introduce the calibrator to your screen—the software tells you where to put it [**Image E**]. Make sure it's plugged in and the lens cap is removed. The lens cap slides on the cable, and can be used as a counterweight, so you hang the cable over the top of your screen, with the calibrator at the front, and the cap at the back. It's a nice idea, but the cap isn't nearly heavy enough, and the calibrator tends to swing around and lose contact with the screen. We tilted our screen backward, as it's on an arm mount, so it made better contact, but still had to hold the cable at the top of the screen to stop it moving. If you need to hold the colorimeter in place for the full calibration process, it not only gets boring, but makes your arm ache, too. Be sure to have your cell phone in easy reach, because you won't be using your computer. The calibration process takes around five minutes, while your screen cycles through black, white, and different colors of varying brightnesses.

6 FINISHED

When the process is finished, remove the calibrator, making sure to put the lens cap back on to protect it, and



E



F

hit the "Finish" button on screen. You're prompted to save the calibration profile, which will be loaded into your video card every time you switch your PC on, and choose an interval at which you'll be reminded to recalibrate your screen. We've chosen to recalibrate ours in a month's time, because the change in color temperature of the ambient light as the year wears on can alter how you perceive your screen's colors. Monitors also change as they age, with subtle differences in the color output between opening the box and now.

7 BACK AND FORTH

The software now shows a series of images, and enables you to flip between calibrated and uncalibrated views [**Image F**], so you can see how much difference it's made. If you've got another screen, you can go on to calibrate it in an attempt to match its output to the calibrated monitor. The Spyder app moves itself to the screen you choose from its drop-down menu, saving you the effort of using the mouse to drag it across.

SOFTWARE CALIBRATION

Windows 10 has its own built-in screen calibration process, but instead of a calibration device, it uses the human eye. The tool can be found in the Control Panel, in an applet called Calibrate Display Color, and it opens as a maximized gray window. It's another wizard, so hit "Next," and you're taken through gamma, brightness, and color adjustments, with sliders to make changes that remove unwanted color casts from the gray bars you're presented with. What you're doing is deciding what looks best to you, trying to get grays to look neutral, and contrast not to be too white or black-heavy. Once you've finished, you can launch ClearType tuning to maximize the clarity of type on your screens, too, which is another process carried out with your eyes, choosing which of the examples you're given looks clearest to you.

Speed Up Boot Times in Windows 10

YOU'LL NEED THIS

SOLID-STATE DRIVE
Windows 10 needs to be running from an SSD..

RUNNING WINDOWS 10 from a solid-state drive (SSD)—rather than a traditional hard drive—is a sure-fire way of speeding up the time it takes for Windows 10 to boot. Solid-state drives have no moving parts, and use flash memory, similar to USB flash drives, which makes them much faster. However, there's a clever trick that you can perform to make Windows 10 boot even faster. This is done by disabling Windows 10's Start Up Delay feature. It was introduced for older hardware, to stop it being overwhelmed, but if you have a modern device, you can safely disable it. This does mean editing the Registry, however, which is a powerful tool in Windows 10. If you follow our steps closely, there should be no issue with this, but remember that incorrectly editing the Registry can cause serious problems. –MATT HANSON

1 BACK UP YOUR PC

Because you're editing the Registry, we recommended that you back up your PC before you begin. In the Start menu, type "Restore Point," and click "Create a restore point." From the window that appears, click "Create" [**Image A**]. You're asked to give the restore point a name. This is a good idea to help you quickly identify it if something goes wrong and you need to restore your PC.

2 OPEN THE REGISTRY

You need to open the Registry so you can edit it. In the Start menu's search bar, type "regedit" and press Enter. Win 10 may show a window asking if you want to allow the app to make changes to your device. Click "Yes," and the Registry opens. On the left-hand side, you'll see a menu system. Open the one that says "HKEY_CURRENT_USER" by clicking the arrow next to it [**Image B**].

3 NAVIGATE THE REGISTRY

With the "HKEY_CURRENT_USER" folder expanded, you now need to navigate to the correct location in the Registry. To do that, first scroll down and open the "Software" folder, then find the "Microsoft" folder, and open that. Next, look for a folder called "Windows," and open that, then go to "CurrentVersion." Finally, find and open the "Explorer" folder [**Image C**].

4 FIND OR CREATE THE SERIALIZE FOLDER

Next, you need to find and open the "Serialize" folder that should be located under "Explorer." If you can't find the folder, don't panic. Make sure you're in the right place, and if it's not there, right-click on the "Explorer" folder, select "New," then click "Key" [**Image D**]. It appears at the bottom of the "Explorer" folder, with its name ready to edit. Type "Serialize" and press Enter.

5 EDIT THE SERIALIZE FOLDER

Now you've found or created the "Serialize" folder, right-click it and select "New" from the menu. Now, choose "DWORD (32-bit) Value" [**Image E**]. Name it "StartupDelayInMSec." Double-click it, and set the value to 0. Press "OK," then exit the Registry. Restart your PC, and you'll notice that Windows 10 starts up faster than before. If you don't notice a difference, check you've followed our instructions.

6 OTHER WAYS TO SPEED BOOT TIMES

There are other things that can speed up the time it takes to load Windows 10. If you're the only person who uses your device, you can make it log in automatically without waiting at the login screen. Press Win-R and type "Netplwiz" [**Image F**]. In the new window, uncheck "Users must enter a user name and password to use this computer," then sign in.

7 CUT THE NUMBER OF STARTUP APPS

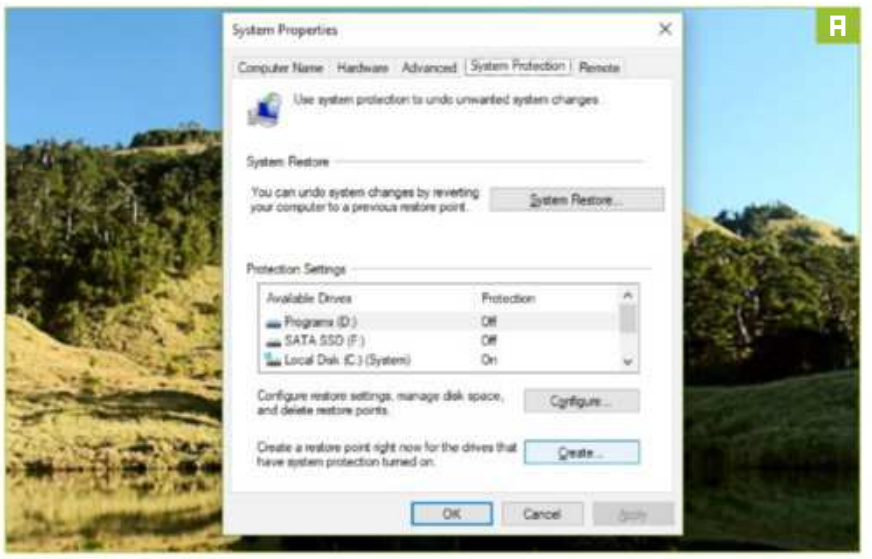
You can also make your PC boot faster by cutting the number of apps that load when Windows 10 starts. Open the Task Manager by pressing Ctrl-Shift-Esc, and in the window that opens, click "Start-up" to see a list of startup apps. Find any you don't use often, right-click them, and select "Disable" [**Image G**]. The "Start-up impact" column can help you choose which apps to disable.

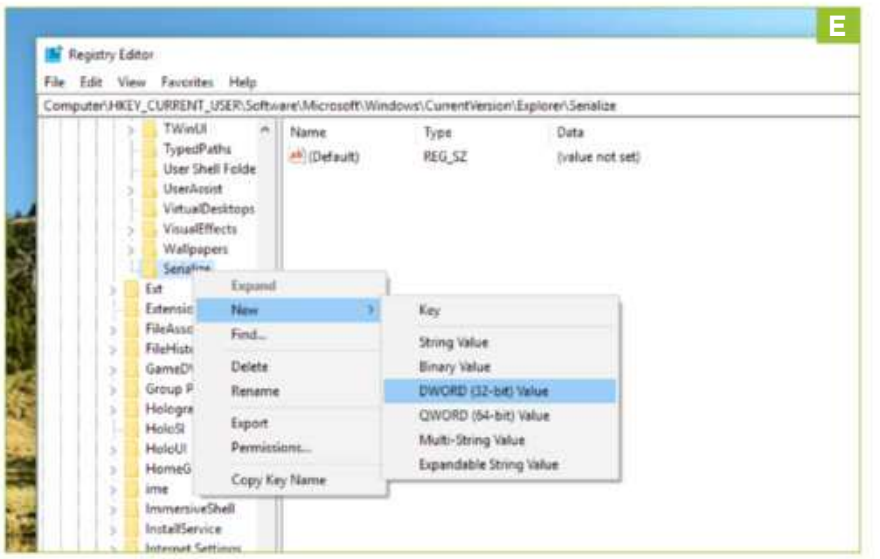
8 BIOS SETTINGS

Many motherboards also have a Fast Boot option [**Image H**] that can make Windows 10 load even faster. When your PC boots, press F2 or Del repeatedly until the BIOS screen appears. This is another powerful tool, so be careful when changing its settings. Look for an option to enable Fast Boot—it may be under "Boot options." If your PC behaves erratically, turn this setting off.

DRIVE DEMANDS

This guide only works if you have Windows 10 installed on an SSD—upgrade your PC with one, if you can, to boost your boots.


A
System Properties
Computer Name
Hardware
Advanced
System Protection
Remote
Use system protection to undo unwanted system changes.
System Restore
You can undo system changes by reverting your computer to a previous restore point.
System Restore...
Protection Settings
Available Drives
Protection
Programs (D:)
Off
SATA SSD (F:)
Off
Local Disk (C:) (System)
On
Configure restore settings, manage disk space, and delete restore points.
Configure...
Create a restore point right now for the drives that have system protection turned on.
Create...
OK
Cancel
Apply


E
Registry Editor
File Edit View Favorites Help
Computer\HKEY_CURRENT_USER\Software\Microsoft\Windows\CurrentVersion\Explorer\Sensalize
Name
Type
Data
(Default)
REG_SZ
(value not set)
Expand
New
Find...
Delete
Rename
Export
Permissions...
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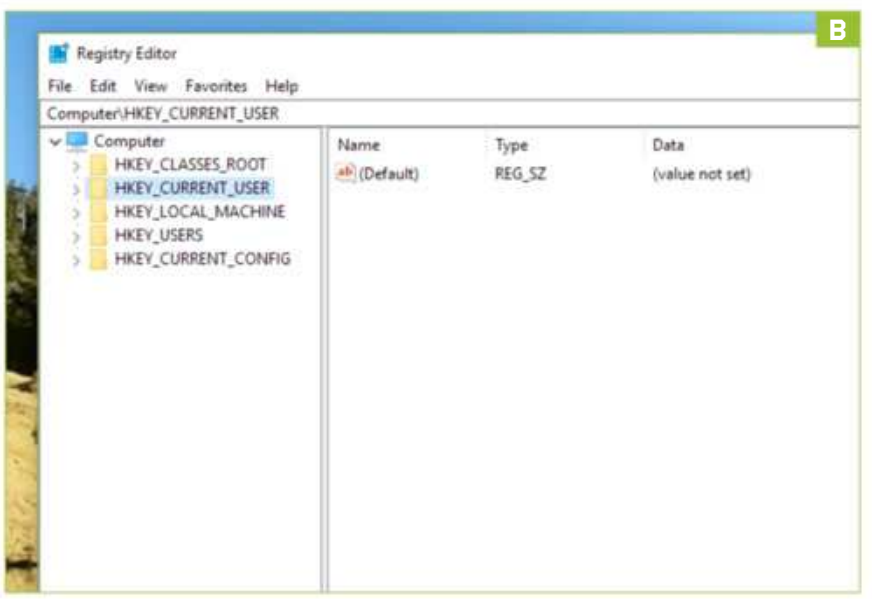
Key
String Value
Binary Value
DWORD (32-bit) Value
QWORD (64-bit) Value
Multi-String Value
Expandable String Value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Registry Editor
File Edit View Favorites Help
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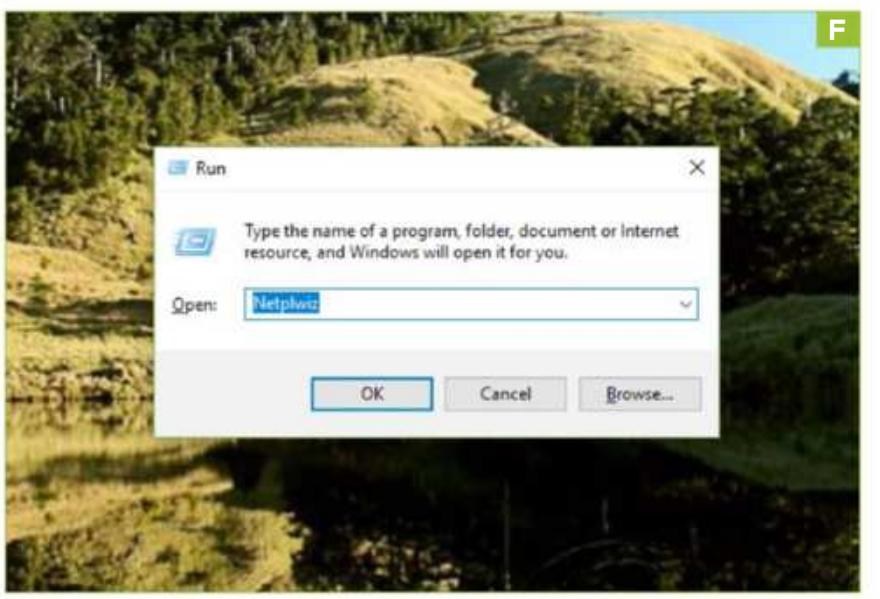
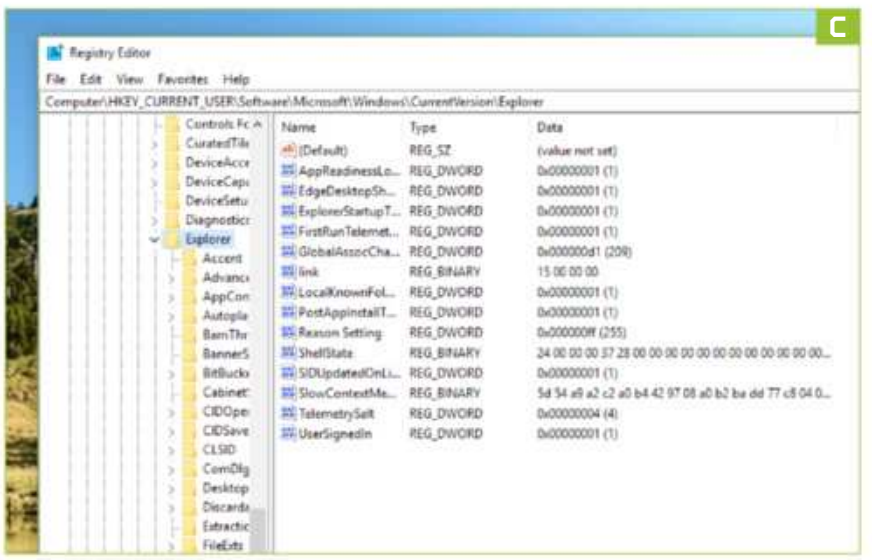
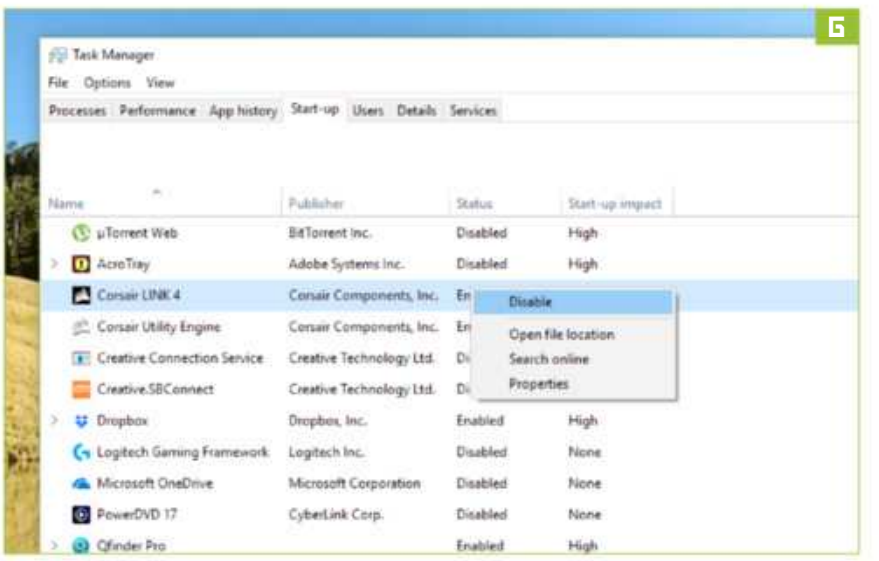
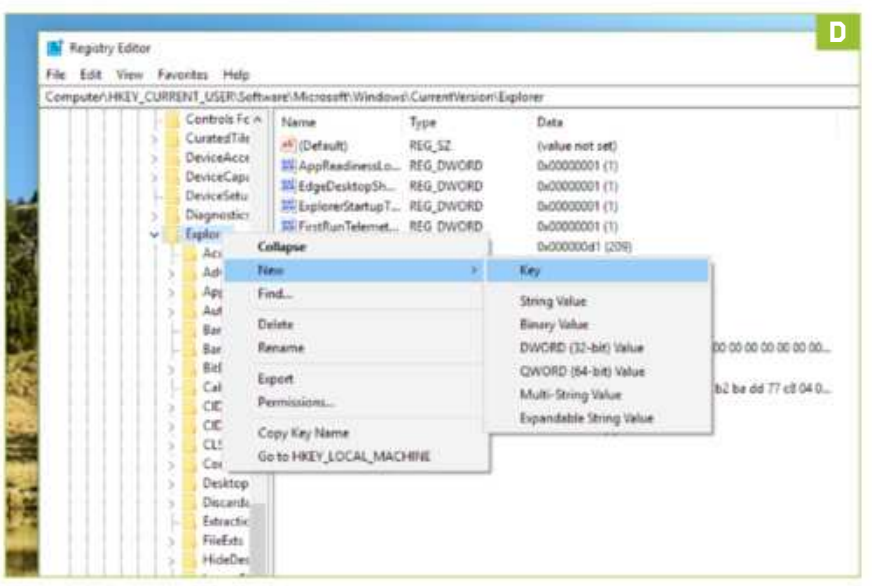
HKEY_CLASSES_ROOT
HKEY_CURRENT_USER
HKEY_LOCAL_MACHINE
HKEY_USERS
HKEY_CURRENT_CONFIG
Name
Type
Data
(Default)
REG_SZ
(value not set)


F
Run
Type the name of a program, folder, document or Internet resource, and Windows will open it for you.
Open:
Netplwiz
OK
Cancel
Browse...


C
Registry Editor
File Edit View Favorites Help
Computer\HKEY_CURRENT_USER\Software\Microsoft\Windows\CurrentVersion\Explorer
Name
Type
Data
(Default)
REG_SZ
(value not set)
Explorer


G
Task Manager
File Options View
Processes Performance App history Start-up Users Details Services
Name
Publisher
Status
Start-up impact
µTorrent Web
BitTorrent Inc.
Disabled
High
AcroTray
Adobe Systems Inc.
Disabled
High
Corsair LINK 4
Corsair Components, Inc.
Disable
Open file location
Search online
Properties
Corsair Utility Engine
Creative Connection Service
Creative Technology Ltd.
Creative.SBConnect
Dropbox
Dropbox, Inc.
Enabled
High
Logitech Gaming Framework
Logitech Inc.
Disabled
None
Microsoft OneDrive
Microsoft Corporation
Disabled
None
PowerDVD 17
CyberLink Corp.
Disabled
None
Qfinder Pro
Enabled
High


D
Registry Editor
File Edit View Favorites Help
Computer\HKEY_CURRENT_USER\Software\Microsoft\Windows\CurrentVersion\Explorer
Collapse
New
Find...
Delete
Rename
Export
Permissions...
Copy Key Name
Go to HKEY_LOCAL_MACHINE
Key
String Value
Binary Value
DWORD (32-bit) Value
QWORD (64-bit) Value
Multi-String Value
Expandable String Value

H
ASUS UEFI BIOS Utility - Advanced Mo
My Favorites
Main
Ai Tweaker
Boot Configuration
Fast Boot
USB Support
PS/2 Keyboard and Mouse Support
Network Stack Driver Support
Next Boot after AC Power Loss

Add Movement to Your Photos

YOU'LL NEED THIS

PHOTOSHOP CC
Subscribe to a suitable Adobe package at www.adobe.com.

WOULDN'T IT BE GREAT if photographs could move? Photoshop contains a Timeline tool to create animations from your photos, and can export each one as a video file.

The method uses the standard Photoshop tools—such as Layers, Opacity, and dragging handles to move and transform—and isn't that difficult to get the hang of. It uses a system of keyframes, where you specify what you want the beginning and end of an animated sequence to look like, and Photoshop automatically animates between these points. You can have as many or as few keyframes as you like, making your animation more complex, or a simple fade-away, like Marty's photograph in *Back to the Future.*

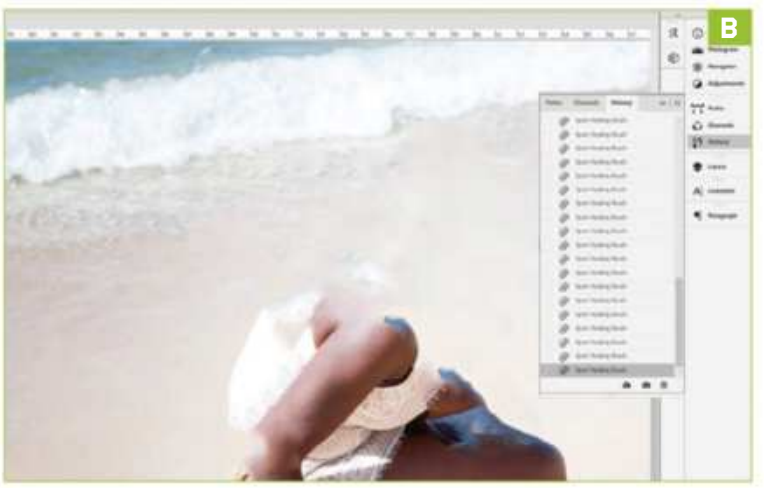
What Photoshop isn't is a full-fledged video editor, and while you can import media into the timeline, it's designed for creating animations from still image layers, so don't go expecting to use it to edit your masterpiece. More advanced users can add Layer Masks, so some elements of their animation appear to pass behind others, still visible through any gaps, but here we're going to explore the basics of the system. **–IAN EVENDEN**

1 CHOOSE YOUR VICTIM

Start by selecting a photo that has a clear subject and a background that's not too distracting. It needs a subject that's going to be easy to cut out. Crop the image to a 16:9 aspect ratio if you like; we're going to be exporting as video at the end of this. Select around your subject—we used the Quick Selection tool, followed by Select and Mask ("Select → Select and Mask")—remembering to get the little internal bits where you can see through to the background, too [**Image A**]. Copy your subject to a new layer with "Layer → New Layer Via Copy," hide the new layer by using the eye icon to the right of its entry in the Layers palette, then set about removing your subject from the background.

2 BRUSH AWAY THE SUBJECT

This isn't as easy as it seems. You might get lucky and be able to use Photoshop's Content Aware Fill ("Edit → Fill," select "Content Aware" from the drop-down). We weren't, so resorted to the Spot Healing tool, which is itself content aware, but operates over much smaller areas, working in small strokes from the edge of the subject [**Image B**]. If this doesn't work, try the Healing and Rubber Stamp tools, which require you to designate a source area before painting over your target. Watch out for repeated features in the background caused by using a source area—these look completely unnatural. You can use the Spot Healing brush to smooth them away if they appear.

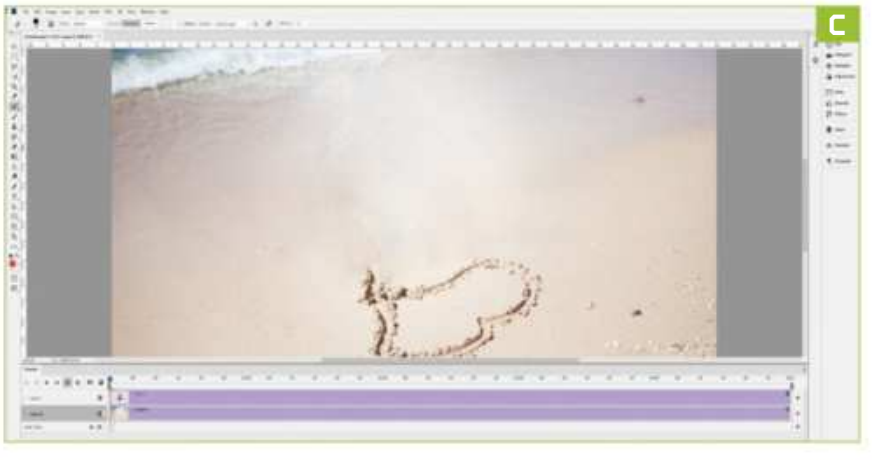


3 ENTER THE TIMELINE

Once your background is complete, with no evidence that there ever was a subject there, double-click the Background layer to turn it into Layer 0, or give it a name. This is a good time to save your work as a PSD file. Then head to the "Window" menu and choose "Timeline." A timeline appears at the bottom of your window, with nothing in it but a button that says "Create Video Timeline." Click it. Each of your layers now has its own space on the timeline, which by default is five seconds long [**Image C**].

4 CHANGE THE POSITION

Drop down the little arrow at the right of each layer on the timeline, and you'll see options for



"Position," "Opacity," and "Style" [**Image D**]. These are the parts you can animate. Select "Position" for your subject layer, and you'll see a yellow diamond appear on the right. This lets you add a keyframe, and you'll see it appear on the timeline as another yellow diamond if you click it. To make your subject move, drag the playhead (the blue triangle with the red line descending from it) to the other end of the timeline, and select the Move tool. Move your subject to where you want it to be at the end of the short animation, and a new keyframe is added at the position you left the playhead.

5 FADING AWAY

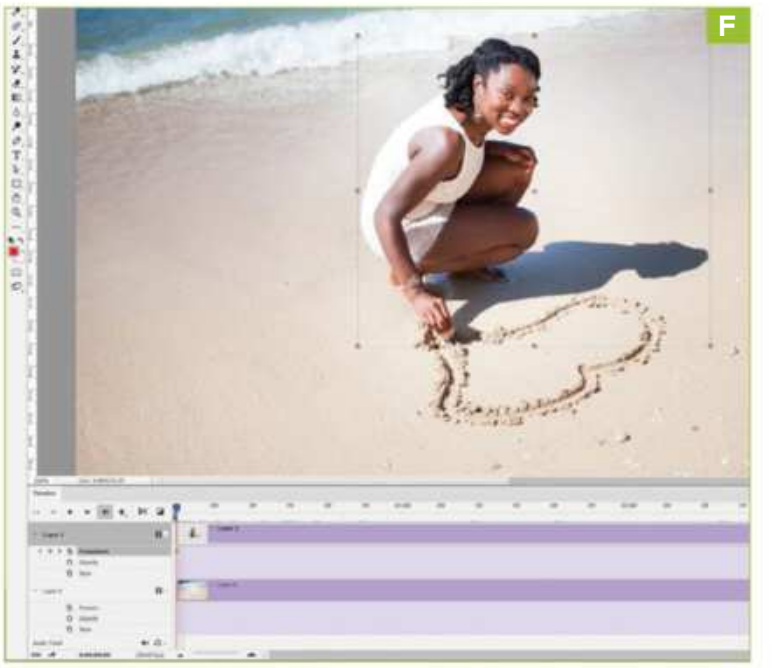
Test it out by pressing the play button at the left of the timeline. You should see your subject glide smoothly across between the two keyframe positions. Opacity works in a similar way [**Image E**]. With the playhead at the left, leave the opacity at 100%, and add a keyframe. Drag it to the right, and change the layer's opacity in the Layers palette to 50%, and a keyframe appears. Drag it further to the right, change opacity to 0%, and you get another keyframe. Play it now, and as your subject moves, it fades away.

6 CHANGE THE SIZE

If you want to make something larger or smaller, you need to change the layer you want to transform into a Smart Object by right-clicking it in the Layers palette, and choosing the option. Now, in the timeline, "Position" has been replaced by "Transform" [**Image F**]. Add a keyframe at the beginning, then drag the playhead to the right, select "Transform," use the controls much like "Free Transform" in the main Photoshop interface, commit the changes, and you get a keyframe. So, we can now make our subject move, fade, shrink, and rotate, all with automatic keyframes.

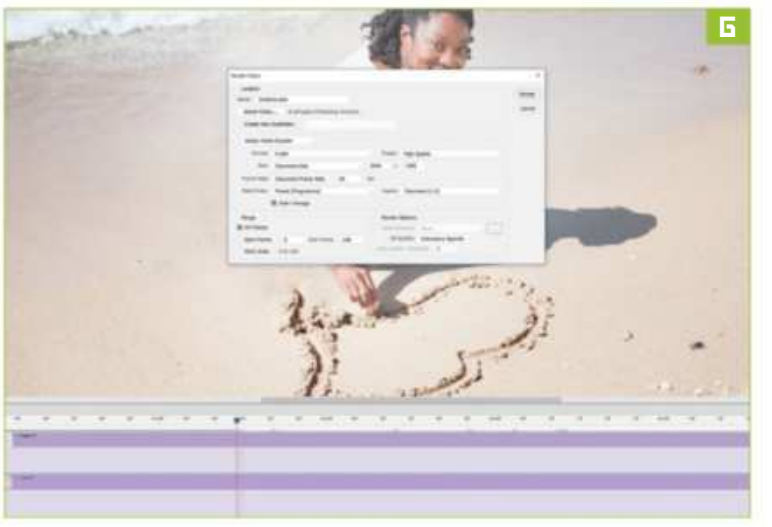
7 GO BACK AND FIX IT

If you're not happy with anything you've done, take the playhead to the keyframe you want to change (or you can jump between keyframes using the little black arrows at the extreme left), make changes, commit them, and the keyframe is updated. "Undo" and the History palette still work on the timeline, so you can roll back your mistakes.



8 EXPORT TO A FILE

Saving your video means rendering it first, because you've been watching a preview all this time—you might have noticed pixelation. Head to the "File" menu and choose "Export → Render video." You get an options box in which you can set the codec used and the dimensions [**Image G**]. This is where cropping to 16:9 comes in handy, because you can resize it to 1920x1080 precisely. Rendering takes a few moments—it's only five seconds, after all—and is faster the more powerful your CPU.



THE GIF THAT KEEPS ON GIVING

The timeline can create an animated GIF, but it's more complicated. You need to enter the Create Frame Animation mode, create a new layer for every frame, then tell the timeline to make frames from your layers, specifying how long each frame should be shown for, and how many times you'd like it to loop. It's much simpler to use the keyframe system, then maybe use a third-party app to convert your video to a GIF. If you're making something to post to Twitter, note that animated GIFs posted there are not actually GIFs; they're converted to MPEG movie files that are allowed to loop like GIFs, as this saves space. GIF is old and inefficient.

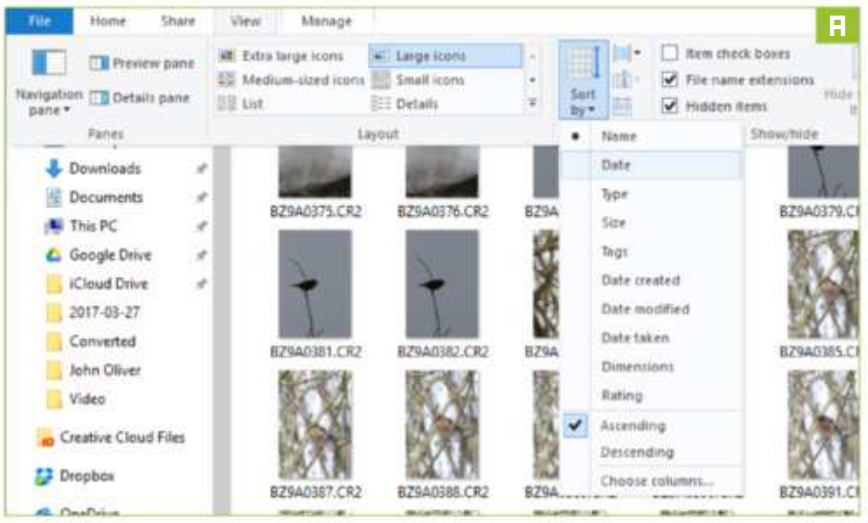
Organize Your Photo Library

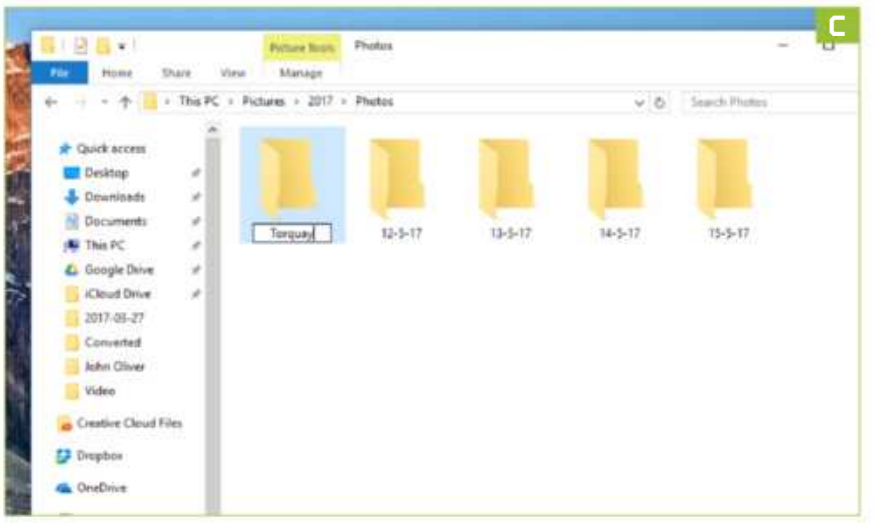
PHOTOS

And lots of them—but you can begin organizing your pix when you only have a few, of course.

WITH MODERN DIGITAL CAMERAS, it's easy to take a lot of photos. It's not like you're wasting film, after all, and with memory cards of up to 256GB easily available and reusable, you can come back from your vacation with a bulging collection of images that need sorting through and putting in order. That's where image organizing software comes in. Being able to arrange your images into a coherent collection, even if it's just by date, is important if you want to be able to quickly find your photos as you accumulate more and more.

Apps are available to help you, one of the best being Adobe's Photoshop Elements 2018, which bundles an image-editing program with a standalone Organizer that takes a lot of the effort out of organization, including GPS tagging and facial recognition. The Photos app in Windows 10 may be somewhat less sophisticated, but it can still make your photos easy to navigate. **–IAN EVENDEN**



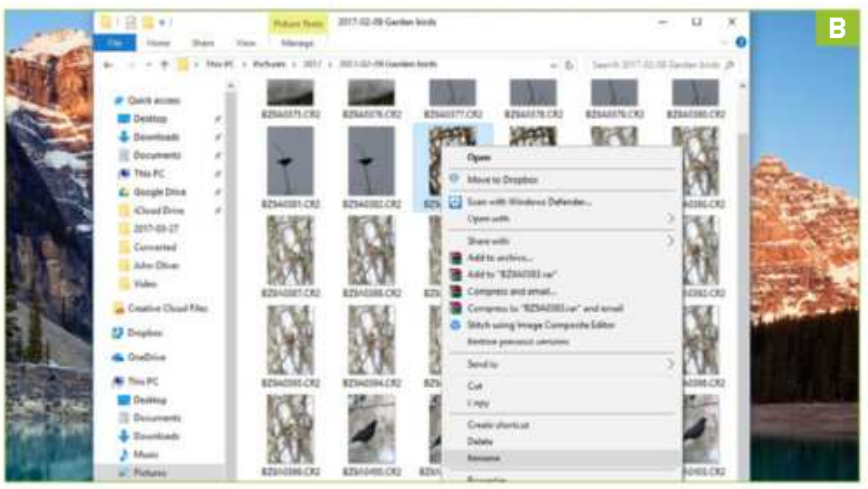


1 IMPORT IMAGES

In Windows, there's a lot you can do to organize a large collection of files, even if it's just splitting them into folders based on the date they were created. When you import photos from your camera, it's likely to do this for you, dumping the resulting dated folders into your Pictures folder. To do it manually, sort the memory card's Explorer window by date [**Image A**], to make things easier.

2 NAME YOUR FOLDERS

It's worth adding more information to the names of image folders, even if it's just the name of the place or event at which you were taking photos. Renaming a folder is simple in Windows: Click the folder, then click the name until it's highlighted in blue, or select "Rename" from the right-click menu [**Image B**]. Once you can edit the name, type a new one, then press Enter.

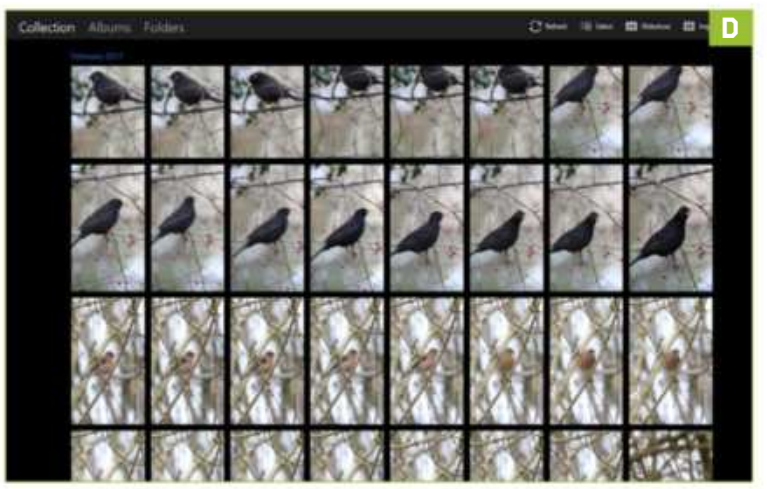


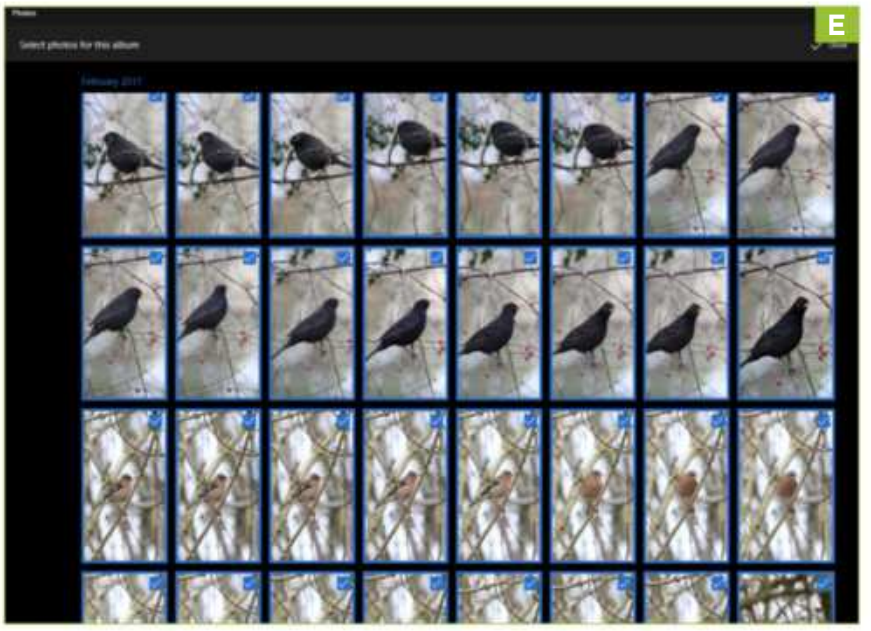
3 BATCH RENAMING

You can batch rename folders in Windows by first selecting them, then renaming the first folder. The following ones take that new name, but add a number after. If you want to rename folders containing photos you took in Torquay, UK, for example, select and right-click them, then select "Rename." Call the first one "Torquay" [**Image C**]. The rest become "Torquay (2)," "Torquay (3)," and so on.

4 PHOTOS IN PHOTOS

Windows 10's Photos app does even more to organize your images. Its Collection view [**Image D**] shows you every photo in the folders you've told it to watch, and the Folders view breaks this up into specific folders. If you use your PC's Pictures folder, this is added by default,





but if you keep photos in another location, such as Google Drive, you need to add that manually.

5 ADD FOLDERS TO PHOTOS

Enter the Photos app's settings by dropping down the ellipsis (...) at the top-right. Choose "Settings," and the first thing you see is "Sources." Click '"Add a folder," and go to the folder you keep your photos in. Click "Add this folder to Pictures," then go back out of Settings to the Collection view to see the newly added photos.

6 ORGANIZING WITH ALBUMS

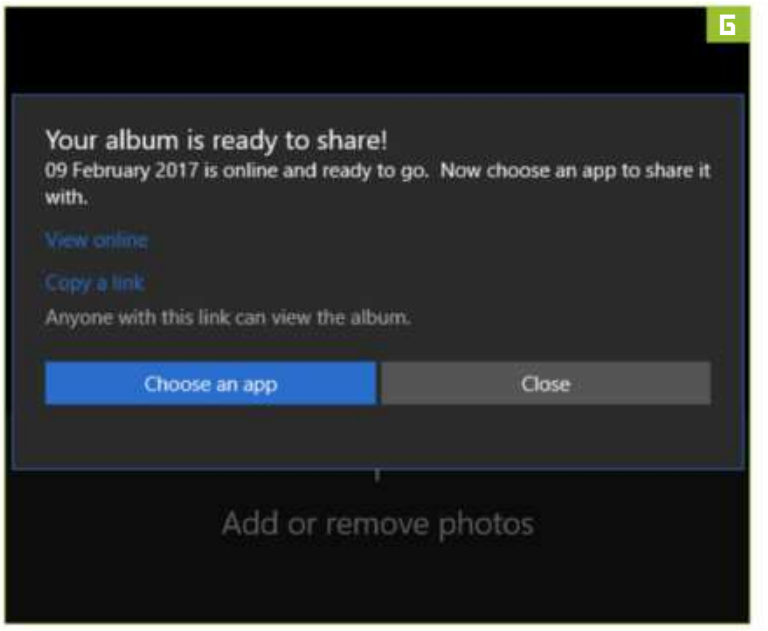
The Albums view has two ways of organizing images: one automatic; the other more hands-on. When you first go into Photos, it scans the folders you've marked in Settings and presents them as Albums—you won't see all the images in the folders, just the ones Photos has picked. It's quite discerning, but doesn't delete anything. You can add important pictures later [**Image E**].

7 ADDING PICTURES TO ALBUMS

Photos does a good job of picking out a single image from a string of duplicates or similar pictures. If there's a photo you want to add to an album, click "Add or Remove Photos" below the album display [**Image F**]. You're presented with every image in the source folder, each with a check box. Checked images appear in the Album, unchecked ones don't. Click "Done" when finished.

8 SHARING ALBUMS

Once you've created an album you're happy with, you can share it in two ways. The first way is to upload it to OneDrive, then send a link to the people you want to view it. To do this, click "Share this Album" below the images, and select "Upload and Share." Once your album has been uploaded, a screen appears confirming the upload, along with sharing options [**Image G**].

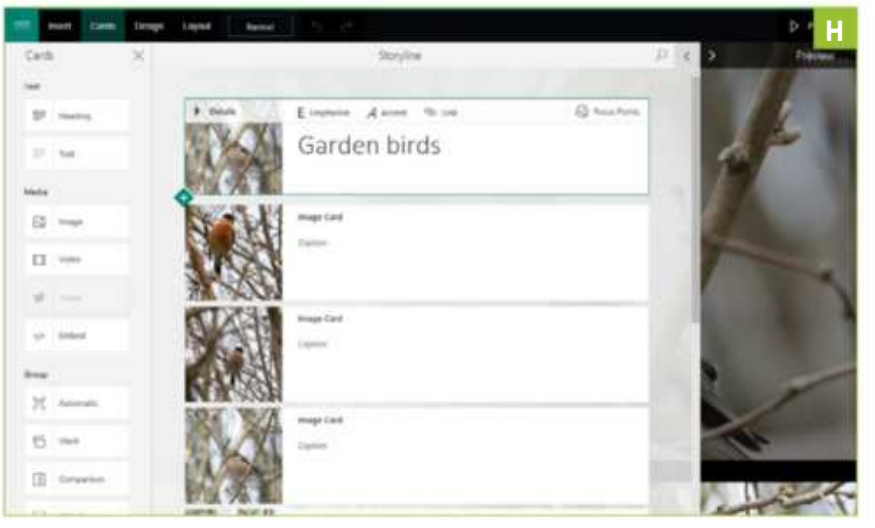

G
Your album is ready to share!
09 February 2017 is online and ready to go. Now choose an app to share it with.
View online
Copy a link
Anyone with this link can view the album.
Choose an app
Close
Add or remove photos

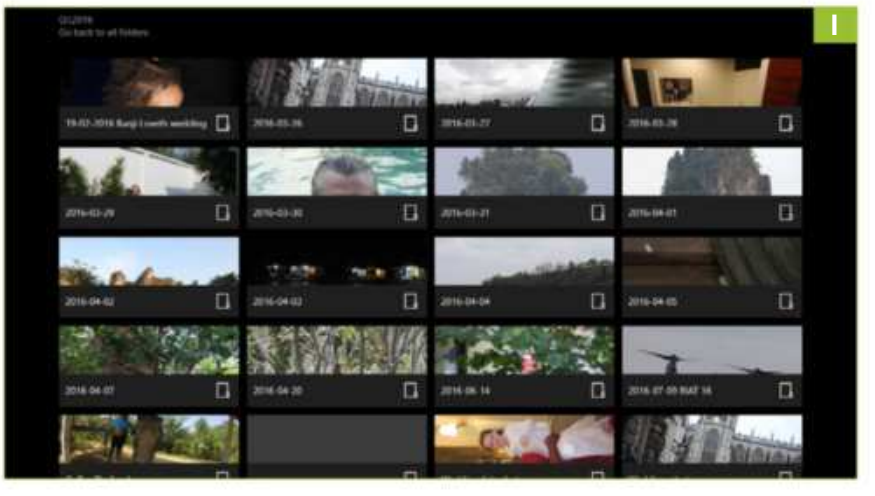
9 SHARE WITH SWAY

The second option exports your images to Sway, Microsoft's web-based presentation app [**Image H**]. From here, you can create a moving slideshow, or anything else you might think of in PowerPoint, before sharing a link to view your presentation in a web browser or mobile app. If you've taken video to go with your images, and uploaded it to YouTube, you can add it to your album in Sway.

10 VIEW YOUR FOLDERS

The folder view is still there in Photos, even though all the cleverness of Albums overshadows it. Click "Folders" in the bar at the top of the interface, and you'll see the folders you added to Photos in Settings [**Image I**]. Double-click one, and you can delve further into its structure. Right-click a photo, and select "Open folder" from the menu that appears to open that folder in Explorer.





BUILD IT

ZAK STOREY, DEPUTY EDITOR

A Tale of Two Machines

From AIO failure to full-built machine, a downgrade becomes an upgrade

LENGTH OF TIME: **2–3 HOURS**

LEVEL OF DIFFICULTY: **MEDIUM**

THE CONCEPT

OH, WE DO LOVE THESE special "Build Its." OK, so it's not a Dream Machine, or some other ridiculously overpriced water-cooled nonsense, but it's a system with a purpose. It's needed for something special. It's not going to be stripped down and relegated to our storage cupboard; it's a rig that's going to be used day in, day out, for a specific job. This time around, it's all about that good ol' deputy editor, pictured above (house style dictates that we don't write in the first-person in most of the magazine, so bear with us here), and it's all because of a hiccup with our Threadripper workstation.

It's not uncommon for us to receive various pre-production samples here, and a while back we were sent a demo full-cover-block Threadripper 360mm radiator. At first glance, it was pretty damn impressive, but after a year's worth of arduous use with our 16-core 1950X, it started to, er, what's the phrase? Bug out. Temps were still well within acceptable parameters, but the whirring noise inside the pump indicated that all was not well.

Before something catastrophic occurred, we decided to bite the bullet, and just ditch it. As is the way of things here, though, where removing one part usually leads to us swapping out several, before we knew it, we'd re-allocated various parts, and built an almost entirely new machine. So, what's the purpose of this build? Well, after failing to get our online video ambitions up and running, we figured it was time to drop into something a little more suitable for our everyday work. That means a Ryzen refresh processor, a GTX 1080, some suitable storage, and a chassis that's a little more compact than the one we had before.

CRISP AND CLEAN

HOT DIGGITY, that price tag sure is something. $2,500 ain't no small sum, so we figured we'd break it down into some percentages, because everyone loves percentages. 23.9 percent of this build's cost is on storage; if you include the RAM, that figure increases to just over 40 percent (all of which can be downgraded, of course). 38.5 percent of the price is spent on the GPU, CPU, and motherboard, and 17.6 percent is on the case, power supply, cooling, and periphery, or anything that makes it look pretty. Everything else (all 3.7 percent) is on the OS. Perfect percentages? In the real world, probably not.

What that should tell you, though, is that you could reduce the cost of this build quite dramatically simply by adjusting the storage. Throw in a 16GB kit (4x 4GB) of G.Skill Trident Z 3,200MT/s memory, with a 250GB Samsung 970 Evo, and a 1TB ADATA Ultimate SU800 SSD, and you're left with a build that looks identical, performs near the same, and costs $1,999 instead.

That aside, why the hardware decisions? Well, in short, after just over a year's worth of struggling to get our video content off the ground (bureaucracy hoops are a nightmare in a big company), it seems as though it's just not going to happen. And because that Threadripper 1950X from the old system was being woefully underused, we thought, hell, let's ditch the big, super-editing rig for something a little more compact, and a little more everyday. Thus the Ryzen 7 2700, 32GB of DDR4 (for all the Google Chrome tabs), and a GTX 1080 to drive the 32-inch 4K panel sitting in front of us.

This build is a little different from our usual ones, because it's a working machine, and has been for some time, so building in the NZXT H400i was done prior to the photo shoot. As such, we're highlighting parts of this build after the fact, rather than during. Don't worry—this is a one-off, while we get in the parts for next issue's next-gen PC.

INGREDIENTS

PART		STREET PRICE
Case	NZXT H500i Matte White	$99
Motherboard	Gigabyte X470 Aorus Gaming 7 Wi-Fi	$229
CPU	AMD Ryzen 7 2700	$280
CPU Cooler	Corsair Hydro H115i Pro RGB 280mm	$140
Fan Cooling	2x Noctua NF-A14 140mm, 1x Noctua NF-F12 120mm Chromax	$73
GPU	MSI GeForce GTX 1080 Gaming X 8G	$480
Memory	32GB (4x 8GB) HyperX Predator DDR4 @ 2,933MT/s	$419
PSU	Corsair RM750X White 750W 80 Plus Gold	$140
Storage 1	512GB Samsung 960 Pro M.2 PCIe NVMe SSD	$215
Storage 2	2TB Crucial MX500 2.5-inch SSD	$400
OS	Windows 10 64-bit OEM	$95
Total		$2,570

1

FRONT I/O NIGHTMARES

IN THE REALM of case advancement, NZXT has been a bit of a whiz-kid over the last few years. From the first Manta to the S340, H700i, and more, when it comes to sleek, stylish cases, materials, and design features, there's little this manufacturer hasn't done to push the boat out. That said, one of our least favorite inclusions is the front I/O panel header. In short, NZXT has shaped this into what looks like a USB header instead. It makes sense, until you match this chassis up with something like a Gigabyte motherboard, where the front I/O connectors are non-standard, spaced-out affairs with a shroud. Unfortunately, without painstakingly using cable extensions, there's no way of connecting up any of the front I/O with the front power button to the Gigabyte board, so we're forced to use a direct power switch on the back of the rear I/O tray (which we're thankful is even there).

2

RADIATOR RELUCTANCE

NZXT HAS INCLUDED a removable radiator bracket at the front of the H500i to allow for easy installation of an AIO—because the H500i's front panel is a single unit, you can't actually remove it from the case. Only problem is, although there's space to run push-pull, with two fans and a rad on the inside of the bracket, plus two fans outside, the bracket itself doesn't support mounting directly to a radiator, because there's a small protruding metal lip that conflicts with the radiator's reservoir. Very specifically, NZXT only intends for front AIOs to be installed in a single push setup. You can get around this with a little fudging, but it does take some work—we used some spacers and a few longer screws. Then, removing the cable hide bar in the middle, we installed the radiator setup, before reinstalling the bar once more.

3 REAR I/O HISTORY?

AHHH, THE PESKY REAR I/O bracket—have we seen the last of you? The one thing we do love about this motherboard is the inclusion of a preinstalled rear I/O bracket. No more messing around, or trying to force it into place along with the motherboard, only to have an unwanted bulge from your USB ports. No sir, just clean lines and easy access. Why this wasn't done before is beyond us, because it removes all the fuss and bother. You can also spot our new dedicated system power-on switch at the rear there, next to the clear BIOS button. It's not ideal, but until we get some front I/O extension pins, it's the best we've got, and to be honest, it works well enough.

4 STORAGE TRANSFERS

FOR OUR THREADRIPPER BUILD, we went a bit overkill with the storage—the reason being, we'd need to back up a ton of video content. In hindsight, that was pretty excessive. This time around, we've dropped the snazzy Intel PCIe SSD and dual RAID 1 10TB hard drives, and instead have transferred over to a single unit: the Crucial MX300 2TB drive we've been using for games all these years. Although end of life now, this little beauty is still going strong, and can still hold all the other programs we'd ever need to run on a personal workstation. For our OS drive, we've opted for an older Samsung 960 Pro 512GB. We had a few of these left over from Dream Machine 2017, so slotting one into this build won't set our inventory back too much.

5 QUICK CABLING

YOU CAN TELL THIS was a quick build by just how fast we sorted the cable situation out in the back. There's very few cable ties here—it was a case of using the features NZXT had installed into the chassis (the cable routing channels, the Velcro straps), then taking advantage of that bottom PSU cover to hide the lot of them. It doesn't look that untidy, if we're honest, and from the front, at least it keeps it clean, and makes it look slick. It's important that we don't go too overboard for these kind of systems, because chances are we'll be swapping parts in and out, as and when we get them, for long-term tests and all sorts of features.

6 CPU CABLING

THE LAST THING we'll point out here is the CPU power. Gigabyte's X470 Aorus board sports both an eight-pin and a four-pin EPS power for cleaner current distribution to the processor. That said, you can get away with just using a single eight-pin, which was fortunate for us, as we can't find the second power cable for the Corsair RM750X White (she's an old girl at this point). We've also sneakily tucked the USB cable for the Hydro out of the way, stuck between the heatsink and a capacitor at the top there. Annoyingly, it's a bit short, so we can't run it anywhere other than straight down the back of the motherboard tray.

1 **We could have mounted two 2.5-inch drives down here on NZXT's removable trays, but we popped just one on the back of the motherboard tray.**

2 **We used five Noctua Chromax fans for this build, but could have added six in the roof as an exhaust.**

3 **GPU sag—she's a cruel mistress. Fortunately, manufacturers seem to be developing better ways to counter this, at least for the next gen of cases.**

MEAN MACHINE

THIS RIG has been a roller coaster of problems. It's been one thing after another, from the operating system install not playing ball, to the drivers self-destructing and causing power state failure blue screens, to Gigabyte's RGB LED software being detected as malware by anti-cheat software, and stopping us from running our gaming benchmarks. To say it's been a less-than-stellar post-build experience is an understatement.

Which is unfortunate, given the role this rig has to play. It has to work flawlessly, day in, day out. To sit here, struggling to log in from time to time because the USB ports have decided not to detect the keyboard, or have the audio drop out for a similar issue, just isn't on. That's why we made such a big fuss about Asus dropping its TUF brand into a more budget-friendly position. They were our workstation boards of choice, and the fact there's no Ryzen equivalent saddens us deeply. Let's be fair: It could just be the sample board we have being quirky, but we sure do miss the plug-and-play nature of an Asus affair. It's a shame, because it's these kind of experiences that ruin your perspective on a brand, and push you toward subjective judgements based on anecdotal evidence—something us journalists have to avoid like the plague.

Now that little rant is out of the way, the build experience itself was pretty enjoyable. NZXT's H500i is an awesome budget-busting chassis, with clean lines, intuitive design features, and enough cooling support for any mid-range build. Yeah, the front radiator bracket might be a bit cumbersome if you're trying to go against the grain and install a 280mm push-pull setup, but for a new PC builder, it's a quick-and-easy, versatile case.

So, the biggy: What's the performance like? Let's preface this by saying that the rig is plugged in to a 32-inch 4K panel, and we've already done some *Battlefield V* testing on it just fine, so can it game at 4K? Yes—just be smart about how you use those settings (although, admittedly, *BFV* was simply whacked up to Ultra, then left). Yup, that's a GTX 1080, playing the latest unoptimized beta of an AAA title at 4K, at a smooth 50-plus fps. Processor performance kicks our zero-point's ass by some margin, but overall the scores are pretty much what we'd expect.

What would we change? Apart from the motherboard, not a lot. Maybe the cable management in the rear, and some additional internal LED lighting perhaps, but all in all, she's a quick, clean rig, with just the right amount of storage, and enough grunt to keep our day-to-day work running smoothly.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	959	1,786 (86%)
CrystalDisk QD32 Sequential Read (MB/s)	3,422	2,740 (-20%)
CrystalDisk QD32 Sequential Write (MB/s)	1,706	1,649 (-3%)
Rise of the Tomb Raider (fps)	93	94 (1%)
Total War: Warhammer II (fps)	55	59 (7%)
Tom Clancy's Ghost Recon Wildlands (Avg fps)	48	47 (-2%)
3DMark: Fire Strike Extreme (Index)	9,128	10,303 (13%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an Intel Core i5-8400, 16GB of Corsair Vengeance LPX @ 2666, an MSI GeForce GTX 1080 Armor, and a 500GB Samsung 960 Evo M.2 PCIe SSD. All tests were performed at 1440p at the highest graphical profile.

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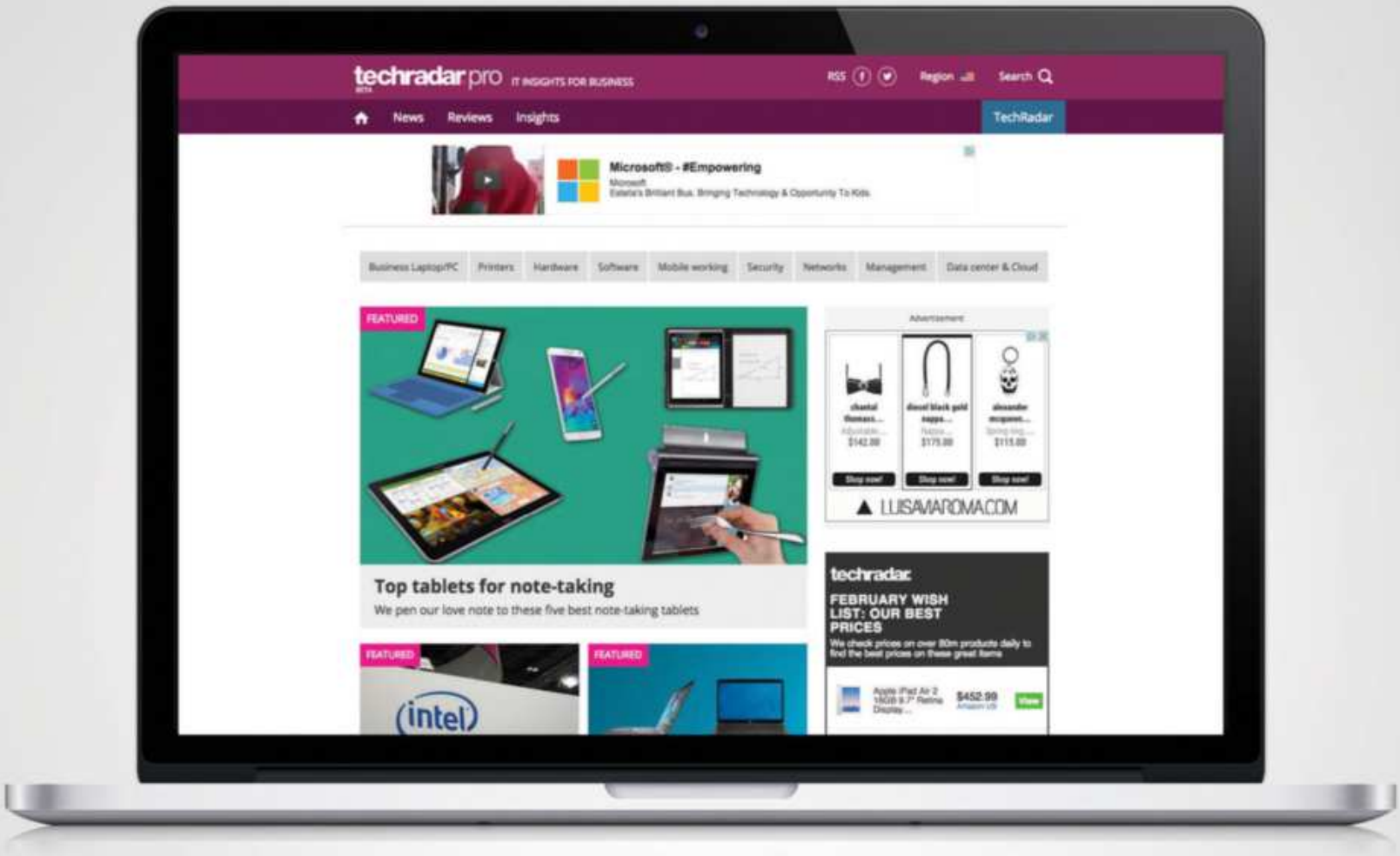
IT INSIGHTS FOR BUSINESS



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REVIEWS

TESTED. REVIEWED. VERDICTIZED.

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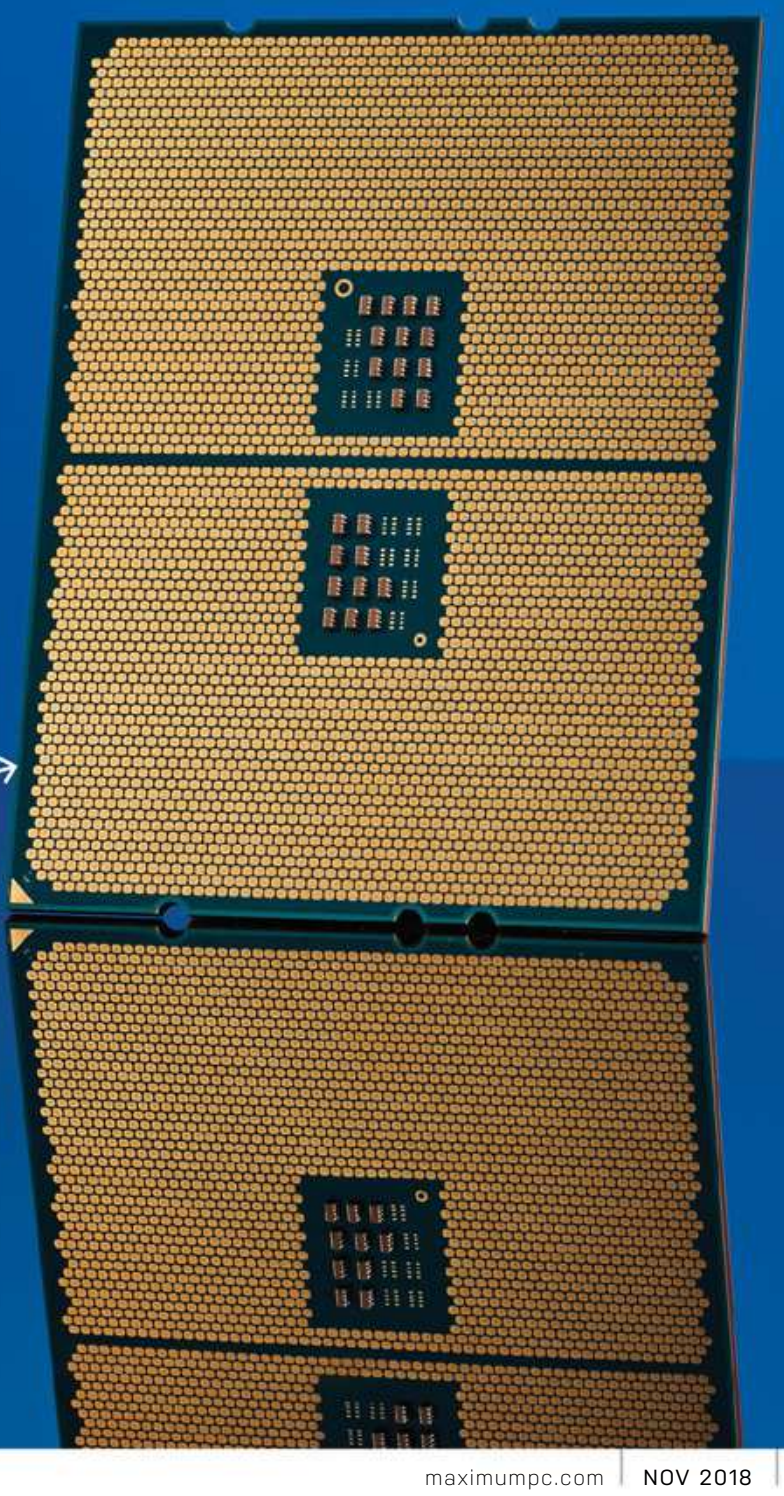

AMD THREADRIPPER 2950X
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AMD Threadripper 2950X

The new king of high-end desktops

AH, THREADRIPPER, where do we begin? That mad assortment of core complexes, intricately stitched together, was enough to revolutionize the HEDT segment into a world unlike one we'd ever seen before, even rattling Intel to its very bones. AMD truly was on to a winner with its Infinity Fabric, and it provided much-needed proof that multi-die packages are certainly the way forward. The age of the monolithic processor is dead. Long live Ryzen.

Or something like that, right? So here we are: second-gen, Threadripper 2, sort of. 12nm transistors, architectural adjustments, memory optimizations, and—more importantly—a bigger product stack this time around. The big question: Is it worth the upgrade? Well, let's get to that.

First up, there's the platform. Given the nature of how Threadripper operates, being essentially a run-off, cut-down, consumer-grade variant of AMD's EPYC server chips, the majority of the I/O lies directly on the processor. There are 64 PCIe lanes tied to the processor, meaning that apart from managing networking, USB, and audio, the chipset has very little to do. Because of that, we're still on the X399 platform. The socket is the same, the chipset is the same, the only thing you'll need to do as a current owner is update the BIOS. For new owners, if the motherboard box doesn't have a "Threadripper II ready" sticker on it, you'll have to flash the BIOS by hand. Fortunately, we've been told that most of the X399 boards will operate and flash the BIOS without even having a processor installed at all. Simply download the BIOS file on to a USB stick, plug it into the BIOS update slot, follow the mobo manual's instructions, and bang, you're good to go.

The second thing you'll notice is the new product stack. Threadripper has now been split into two categories: the X series, aimed at enthusiasts, gamers, streamers, and amateur content creators; and the WX series (which somehow stands for workstation), aimed at more premium content creators, CAD CAM developers, and those who will benefit from more cores (currently, for instance, Premiere Pro doesn't scale with anything beyond 18 cores). What you're left with is essentially four brand new products: the 12-core 2920X at $650, the 16-core 2950X at $900 (reviewed here), the 24-core 2970WX at $1,300, and the juggernaut that is the 32-core 2990WX at $1,800.

The difference between X and WX is mostly down to the number of dies incorporated into the chip, and how they access memory. In the X's case, there are two dies with access to two memory channels each. In the WX's case, there are four dies in total, but only two can access the memory directly; the other core complexes have to send their memory requests through the original two dies, which increases latency. Additionally, with four dies per chip, the Infinity Fabric only has a maximum bandwidth of 25GB/s.

But back to the original question: Is Threadripper+ worth it? Unfortunately, it's one of those "it depends" brackets. We'll let the benchmarks do the talking here, as there's a lot to cover. If you need more cores, the 2990WX and 2970WX are the place to be. For those already on the 16-core parts, however, there's very little reason to plump up for the newer chip, as performance is well within a 5–10 percent margin, memory latency has improved, power draw is comparable, and in-game performance slightly more consistent, but apart from that, the impressive nature of this processor is the same. What has changed, however, is the price, and with a $100 price drop, at $900 for a 16-core chip on a now more mature platform, that's darn tempting. **–ZAK STOREY**

PROCESSOR BENCHMARKS

	AMD Threadripper 2950X	AMD Threadripper 1950X
Cinebench R15 Single (Index)	**178**	166
Cinebench R15 Multi (Index)	**3,192**	3,010
Tech ARP's X264 (fps)	**66.82**	64.57
Fry Render (Seconds)	**81**	83
AIDA64 Memory Latency (Nanoseconds)	**86**	87.6
AIDA64 Memory Bandwidth (MB/s)	75,393	**75,412**
Power Draw Idle/Load (Watts)	114/278	**91/271**
Total War: Warhammer II (fps)	**76**	75
Ghost Recon Wildlands (fps)	**56**	**56**
Middle Earth: Shadow of War (fps)	**84**	**84**
3DMark Fire Strike (Index)	18,890	**18,899**
Maximum Overclock @ Voltage (GHz @ V)	**4.3 @ 1.42**	4.0 @ 1.4
Price to Performance (Index)	3.55	**4.01**

Best scores are in bold. Our test bed consists of an Asus ROG Zenith Extreme, 32GB (4x 8GB) of Corsair Dominator Platinum, an Nvidia GeForce GTX 1080, and a Samsung 850 Evo 500GB SSD. All games were tested at 1080p on the highest graphical profile, with average fps noted.

VERDICT **9**

AMD Threadripper 2950X

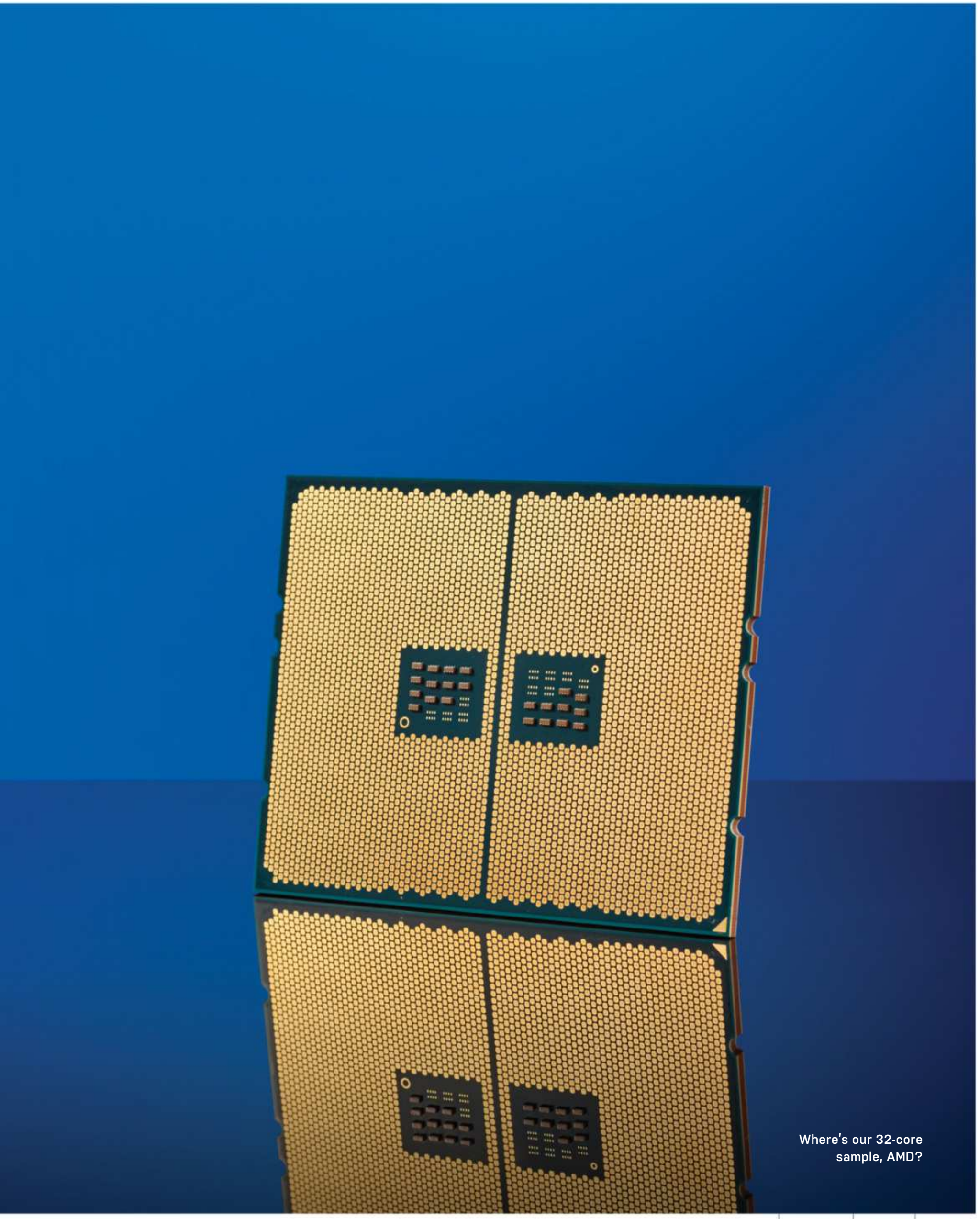
RADICAL Great value; good clock speeds; better memory performance.

RIDICULOUS Not a huge difference in overall performance.

$900, www.amd.com

SPECIFICATIONS

Base/Turbo Clock	3.5GHz/4.4GHz
Cores/Threads	16/32
Lithography	12nm
Cache	L3 32MB
Memory Support	128GB DDR4
Memory Channels	4
Max PCIe Lanes	64
TDP	180W



Where's our 32-core sample, AMD?

Nvidia GeForce RTX 2080 Founders Edition

A revolutionary ahead of its time?

THE FUTURE OF GRAPHICS CARDS and gaming is about to experience the next revolution; at least, that's the marketing behind Nvidia's GeForce RTX cards. When Nvidia demonstrated real-time ray tracing running at 24fps on a DGX Station earlier this year, it felt like a lot of hoopla over something more beneficial to Hollywood than PC gamers. Six months later, we're looking at a single graphics card that can outperform the DGX Station, at just $799. Great news, at least for enthusiast gamers with deep pockets.

The technology crammed into Nvidia's Turing architecture is certainly impressive. The CUDA cores have been enhanced, promising up to 50 percent higher performance than on Pascal, and there's more of them. Next, add faster GDDR6 memory, improved caching, and memory subsystem tweaks that also provide up to 75 percent more effective memory bandwidth. Then toss in some RT cores to accelerate ray tracing, and Tensor cores for deep-learning applications.

Nvidia also makes some changes with the new Founders Editions. Gone is the old blower cooler, replaced by dual axial fans, dual vapor chambers, and a thick metal backplate. The 2080 FE is quieter than the 1080 FE, though the backplate does get hot to the touch. The 2080 FE also comes with a 90MHz factory overclock, with further manual overclocking an option. VR fans will like the new VirtualLink connector, which can provide power, data, and HBR3 video over a single cable (though you need a new headset that supports the standard).

All these improvements make the RTX 2080 FE a recipe for success; what could go wrong? There are several concerns. First, games will need to be coded to use ray-tracing and deep-learning enhancements. Those are coming, with 11 announced games featuring some form of ray tracing, and 25 that use Nvidia's new DLSS (see Tech Talk, pg. 17). But at launch, none are available, and we haven't had time to analyze the DLSS demos. But the bigger problems are price and performance.

Compared to the GTX 1080, the RTX 2080 registers a healthy 38 percent average improvement in gaming performance at 4K, and a 36 percent improvement at 1440p. There are a few games where it even comes close to a 50 percent jump. But we had similar performance from the GTX 1080 Ti, which is 34 percent faster than the 1080,

and we're nowhere near the advertised 50 percent average improvement. With the cryptocurrency induced graphics card shortage behind us, and the next-gen cards arriving, 1080 Ti cards are selling for under $650 and dropping, making a $799 Founders Edition a question of faith.

Do you believe that enough games that leverage the new ray-tracing features will arrive in time to warrant jumping on the bandwagon? And will they run well enough on the RTX 2080, when even on the beefier RTX 2080 Ti many appear to struggle? Are you willing to pay more money for a card that's only incrementally faster on existing games than the former champion? Good questions, but there's no clear answer.

We're optimistic about the Turing architecture, as it represents the biggest improvements to the graphics rendering pipeline we've seen since the first GeForce cards. In another year, or even six months, the RTX 2080 could be a kick-ass product. But right now, it carries a high price and lacks the raw performance to back it up. It's not a revolution—yet. **–JARRED WALTON**

BENCHMARKS

	Nvidia GeForce RTX 2080 FE	Nvidia GeForce GTX 1080 Ti
Assassin's Creed Origins (Avg fps)	**82/53**	78/50
Deus Ex: Mankind Divided (Avg fps)	**74/41**	70/38
Far Cry 5 (Avg fps)	**107/57**	105/56
Grand Theft Auto 5 (Avg fps)	**85**/44	**85/45**
Middle Earth: Shadow of War (Avg fps)	**87/49**	83/48
Rise of the Tomb Raider (Avg fps)	**90/49**	89/**49**
Total War: Warhammer II (Avg fps)	**96/56**	95/**56**

Best scores are in bold. Our test bed consists of an Intel Core i7-8700K, 16GB of G.Skill DDR4-3200, an MSI Z370 Gaming Pro Carbon, and a 500GB Samsung 960 Evo M.2. All games are tested at their highest graphical profile with AA turned up, at 1440p, and 4K

VERDICT **8**

Nvidia GeForce RTX 2080 Founders Edition

LES MISERABLES Beats 1080 Ti; ray tracing; deep learning; great design.

EVITA No current ray-tracing games; only just faster than 1080 Ti; expensive

$799, www.nvidia.com

SPECIFICATIONS

GPU	TU104
Lithography	TSMC 12nm FinFET
Transistor Count	13.6 billion
CUDA Cores	2,944
Texture Units	184
ROPs	64
Core/Boost Clock	1,515/1,800MHz
Memory Capacity & Type	8GB GDDR6
Memory Speed	14GT/s
Memory Bus	256-bit
TDP	225W
Display Connectors	2x DisplayPort, 1x HDMI, 1x USB Type C

$150 more than a 1080 Ti? How much is that ray tracing worth?

MSI Trident 3

Attack of the consoles

LOVE 'EM OR LOATHE 'EM, pre-built systems provide an accessible entry point into the PC gaming ecosystem. After all, not everyone has the time or desire to bone up and get to grips with building a rig, so why not cut the fat, and get straight to the meat of it all with something like the Trident 3?

It seems like a solid idea. The spec is good for the price—Core i7-8700, GTX 1070, 16GB of DDR4—and you get a hefty storage solution as well. Coupled with a form factor matching the likes of the Corsair One's sophistication, it's a shoo-in, surely?

Not quite—there are a few problems. Despite MSI claiming on its website that the Trident 3 is "easily accessible and ready to be upgraded at any time," removing the rear panel voids the warranty for the entire unit. Mind you, you'd be hard-pressed to find out how to take it apart, because it requires prying off the bottom fascia, and removing a plethora of screws and plastic to get at the hardware.

Next up on the long list of issues is the bloatware. Look, we get it—for folks who just want a plug-and-play system, pre-installing chipsets, drivers, and the like can be a good idea. But loading in proprietary backup software and a healthy dose of Norton Antivirus? Hmm, we're not so keen. To be honest, Windows Defender isn't that bad nowadays, so why the bloat? Come on, MSI, you can do better than that.

On to the testing. Or lack thereof, at least at first. Why, you might you ask? Well, MSI had promised us one of the latest Trident 3 Arctics, complete with Intel Core i7-8700, 16GB of DDR4, and a GTX 1070: the world's smallest system capable of dishing out the frames at both 4K and 1440p. However, on closer inspection, HWMonitor was reporting that the graphics card was actually a 6GB GTX 1060. When combined with a i7-8700, that spec doesn't currently exist, at least not in Arctic White. You can't buy it anywhere. We were then pointed toward a similar spec online, featuring the white variant with a GTX 1060, but the processor at its heart was a Core i5, not the i7-8700 we had.

MYSTERY MACHINE

The mystery deepened, so we decided it was time to crack open the old girl, and see what was inside. After carefully breaking into the lustrous white chassis, rather frustratingly removing the graphics card, and taking out the integrated CPU cooler, we discovered two things. First up, the GPU itself had no designation on it; the only notable clue was the MSI Aero ITX cooler. Removing that and looking directly at the stripped-down die revealed a GPU name of GP106-401 A1, which to our knowledge, doesn't correspond to any known Nvidia silicon, outside of the GP106 being the general designation for the GTX 1060 series—that suggests that this might be an alternative SKU. On to the CPU, and after removing the heatpipe arrangement, we were greeted by an Intel Confidential CPU. That's nothing new—if you're a regular reader of our review pages, you'll have likely spotted this on a number of chips—but these processors are typically only supplied to reviewers and engineers prior to the launch of a processor, and not used in all-in-one systems way after launch.

This puts us in a pickle. You can buy this spec, in the black variant, with keyboard and mouse, for $1,300. But when it comes to the white model pictured here, we can't confirm its price. Build quality overall is good. It's impressive, tight, difficult to upgrade, but not impossible. That said, if you do upgrade, voiding the warranty, all you're left with is a proprietary motherboard, a skinny chassis, and a fairly lackluster power supply (180W). There's no doubt in our eyes that this machine is ideal for VR, but 4K gaming? Hmm, not really. Definitely not for the price. **–ZAK STOREY**

VERDICT 7

MSI Trident 3

METAPHOR Intriguing design; good cooling; performs well; price is within reason; includes keyboard and mouse.

MALAPHOR Warranty void when upgraded; price could be more generous; internal hardware confusing; spec not actually available in this color.

$1,300, www.msi.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,152	1,254 (9%)
CrystalDisk QD32 Sequential Read (MB/s)	3,400	776 (-77%)
CrystalDisk QD32 Sequential Write (MB/s)	1,720	334 (-81%)
3DMark: Fire Strike (Index)	11,101	11,431 (3%)
Rise of the Tomb Raider (fps)	60	55 (-8%)
Total War: Warhammer II (fps)	46	50 (9%)
Tom Clancy's Ghost Recon: Wildlands (fps)	39	40 (3%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an AMD Ryzen 5 1600, 16GB of Crucial Ballistix Sport LT @ 2,666, an EVGA GeForce GTX 1060 3GB, and a 250GB Samsung 960 Evo M.2 PCIe SSD.
All tests were performed at 1080p at the highest graphical profile.

SPECIFICATIONS

Processor	Intel Core i7-8700
Graphics	Nvidia GTX 1060 6GB
RAM	16GB 2,400MHz
Motherboard	Proprietary MSI Z370 ITX
Primary Storage	256GB M.2 PCIe SSD
Additional Storage	2.5-inch 1TB SATA HDD
Cooling Solution	Slim integrated blower cooler
PSU	180W external power brick
Case	MSI Trident 3
Warranty	One year parts and labor

Bloatware—why?

Philips 436M6

Beautiful, but only from a distance

CONVERTING AN HDTV into a large-scale PC monitor—which is basically what Philips has done with the 43-inch 436M6—isn't a new idea, but nor is it necessarily a bad one. That's especially true if it's done well. Happily, Philips has good form in this area.

In the 1080p era, HDTV conversions had limited appeal; a 2K pixel grid stretched over 40-plus inches of LCD panel made for big, fat, ugly pixels. Today's UHD or 4K sets, however, have plenty when it comes to pixels. TV tech of late also matches or beats the best monitors in other areas. Thanks to broad adoption of various HDR standards in the mainstream TV market, wider color spaces and supercharged contrast capability is becoming the norm.

TV prices also look like amazing value compared to monitors, in no small part thanks to the economies of scale in what is a far larger consumer market. The challenge, then, for this panel, is to deliver all that next-gen UHD and HDR TV goodness along with critical optimizations for monitor usage, at a price that makes a lot of conventional monitors look expensive.

Out of the box, the 436M6 packs an intriguing feature set. It's one of the first PC monitors to be granted full VESA DisplayHDR 1000 certification. Among other criteria, that means it must be capable of a minimum of 1,000 nits of brightness, local dimming for heightened contrast, wide color gamut support, including 90 percent of the DCI-P3 space (in fact, it achieves 97.6 percent), and native 8-bit-per-channel image rendering (and 10-bit processing). A hefty list of features.

To that Philips has added some PC-centric extras. Most notable are low input lag, which can be a problem on cheaper HDTV conversions, adaptive sync in the form of AMD's FreeSync, and USB-C support for single-cable connectivity. Nice. Those additions do not, however, entirely disguise the 436M6's TV origins. They are obvious from the fixed stand and the fact that you can only access the OSD menu via a recalcitrant remote control. Neither are deal breakers, but you need to be aware that screens like this are less flexible when it comes to setup and desk space.

Potentially more problematic is the image quality. We'll come to the HDR shizzle in a moment, because the first thing you notice is an odd character to the basic image quality. It's as though colors are being interpolated via a very low fidelity panel. The upshot is a mottled or meshed quality to the image that's redolent of color newsprint. It's also similar to pentile OLED displays in smartphones—and for good reason. Instead of conventional RGB subpixel arrangement, this TV-sourced VA panel is ordered BGR, or blue, green, red. That immediately causes problems with anything that relies on assumptions about subpixels, such as font smoothing. The panel also uses a form of subpixel offset or dithering to achieve wider color support.

The bottom line is that at normal monitor viewing distances, the image quality is problematic. You just don't get nice, uniform colors. At a distance, the problem disappears. But that distance is beyond any desktop usage scenario. Of course, if you're using this as a display purely for playing games in a living room context or similar, it may not be a problem. Certainly, in that scenario, this screen is incredibly punchy. The way specular highlights—the shine from a piece of metal, say—or point light sources leap out of dark game scenes blows away a non-HDR panel. It's genuinely different and dramatic. It doesn't make this a great all-around monitor, which it isn't, but if you're looking for a big-format display for games or movies, the 436M6 is a spectacular if flawed choice. –**JEREMY LAIRD**

VERDICT **7**

Philips 436M6

HDR Incredible contrast; some nice PC-centric features.

SDR Oddball subpixel arrangement and color processing; requires 10ft-plus viewing distances.

$900, www.philips.com

SPECIFICATIONS

Panel Size	43-inch
Native Resolution	3840x2160
Pixel Density	102 pi
Panel Type	VA
Maximum Refresh	60Hz
Response	4ms
Contrast	4,000:1
Display Inputs	HDMI, DisplayPort, USB-C
Connectivity	USB C
VESA Mount	200 x 200mm
Warranty	Three years

Ten-foot beauty: Philips's latest HDTV conversion requires distance viewing.

Razer Nommo Pro 2.1

Razer gets serious about desktop sound

WOW! WE WEREN'T expecting that. Just as we were Googling studio monitor deals to find out exactly how much professional-grade audio you can get for $500—the answer's "a lot"—the Nommo blasted us into submission. This is, if you can believe it, a wonderfully articulated 2.1 speaker system, which—despite the subwoofer looking like a 1:1 scale trashcan—doesn't overdo the low end. It sounds.... Well, it sounds like a high-end speaker system,

A similar revolution has taken place in the headset market. Where once there were tinny sounds and apologetic tribal designs on each earcup, there's now audiophile-friendly, sonorous audio from SteelSeries, HyperX, et al. "Gaming headset" is no longer shorthand for "They've botched the sound, but it comes with a detachable mic." Gaming speaker systems, though....

That's a different story. Actual speakers aren't usually part of a traditional gaming setup. You're either a dedicated gamer with your preferred headset, or you dabble in music production, too, and cram a pair of massive studio monitors on your desk. Manufacturers don't often appeal to us directly as gamers with 2.1 systems.

We're so glad Razer did in this instance. The enormous subwoofer will definitely make every gunfight more intense, every explosion more likely to force you to look around and check the windows are still intact. Y'know—everything you want in a gaming sound system. But it's also distortion-free at high volumes, and doesn't muddy up the mix by pushing low-end frequencies louder than anything else. It's remarkable restraint for a product that includes RGB speaker bases.

Which brings us to the "2" in that 2.1 system. These speakers are available separately, in RGB or tasteful varieties, and they're compact enough not to impinge on your setup space too much. There are

We deeply approve of the Nommo Pro's resemblance to *2001's* obelisk.

no controls on the speakers, however—it's all controlled via a hub connected to the subwoofer via a proprietary connection. On that hub you can switch between Bluetooth, analog, and USB inputs, and move the volume up and down via a satisfying wheel. It has white LEDs to indicate volume and everything. But then, y'know—$500.

We did have a few pains getting Windows to play nicely with the Nommo 2.1 at first, but only because the hub had defaulted to Bluetooth output rather than USB. Once fixed, a sonic bath of rich, warm, powerful, and eloquent music followed. Enemies were made in the vicinity, of course, but that's the price you pay for listening to old Nine Inch Nails EPs and deathcore tracks at bone-powdering volumes. All in the name of testing, you understand.

So, then: Its sound is stellar, it looks attractive—although we vastly prefer the RGB switched off—and it's easy to use. Is there anything to rain on the Nommo's parade? Not really. At $500, it is technically too expensive—there's a "gaming" premium bloating that price slightly, as you'll see when you look at what manufacturers such as Yamaha roll out in terms of 2.1 systems and studio monitors in the same price range. But we're going to look past that, because the Nommo 2.1 is more fun. Who cares if you can't mix on them—they sound amazing in any other scenario. Your only considerations to the contrary should be practical—is a downward-firing subwoofer the size of Delaware a great idea in your third-floor apartment? Do you have space for it under your desk? If you can navigate these questions with sensible solutions, there's only the sizeable price tag standing between you and grin-inducing, silly-good sound. **–PHIL IWANIUK**

VERDICT
9
KICK ASS!

Razer Nommo Pro 2.1

NOMMO NOMMO YAY Well constructed; smart control hub; sounds fantastic.

RAZER BURN Slightly overinflated pricing.

$500, www.razer.com

SPECIFICATIONS

Frequency Response	35Hz–20KHz
Connections	USB, Bluetooth 4.2, optical, 3.5mm
Driver Size	3-inch
Tweeters	0.8-inch
Subwoofer	6-inch

Corsair K63 Wireless Mechanical Gaming Keyboard

Flash keys with full freedom

TO START, AND BEFORE we move on to the more interesting aspects of this tenkeyless keyboard, we need to talk about its size. Not the narrow width, which is a natural result of chopping off the number pad, but rather the exaggerated width of the main keyboard layout. Whoever came up with this grid, which squashes the left-hand functions slightly, yet stretches the main cluster about two thirds of an inch wider than any other standard keyboard, must be a little sadistic. You'll spend at least your initial hours with the K63 fighting your muscle memory and mistyping. By the time you attempt to reach the arrow cluster with your right pinky, you'll spot that the left key is placed almost precisely where the down key is on most other layouts. It's infuriating, at least at first.

That's about the only big design mishap here, though. The keys—individually illuminated with blue LEDs, and glowing over a blue base plate—are bright and attractive, with a wide, bold font making the most of the above-switch lighting. The switches themselves are stock Cherry MX Reds, which (for our money) offer one of the best combinations of bite and low noise, though their actuation point is relatively deep, and they could be accused of being a little boring by xtreme 'boardists. We wouldn't necessarily argue that fact.

You get extra buttons—media controls on the top-left; volume on the right—and a two-level brightness control for the lighting, as well as a Windows/context key lock. There's a textured space bar, which is nice, and flipping the reassuringly weighty board over leads you to Corsair's amusingly passive-aggressive take on the standard warning: "Some experts believe that use of any keyboard may cause serious injury to hands, wrists, arms, neck, or back." If only it had sarcastic italics to go with it.

If you do care about your wrists, there's a pretty lame hollow plastic palm rest included, which tapers to a point and can't, despite its "soft touch" texturing, grip your skin in any meaningful way, leading to a particularly slippery typing experience. It does, though, clip on, which is handy when you consider the K63's key feature: It's wireless, either operating through Bluetooth or, preferably, through Corsair's own encryptable 2.4GHz wireless protocol, which gives it a claimed 1ms response time. That is, just as with Logitech's similarly responsive Lightspeed wireless connection, akin to wizardry, and had we not experienced a couple of odd dropouts (in an admittedly cloudy 2.4GHz environment), we'd have been as blown away as we were by its competitor; alas, any loss of signal, particularly one in close proximity to the USB receiver, is a mark down.

You can pair the K63 with a couple of devices at one time, switching instantly between Bluetooth and 2.4GHz using the under-utilized Fn key, which is mercifully tucked in the right function lane, rather than pushing the left Ctrl key around. This keyboard also scrapes back a little of that lost goodwill by running perfectly well in wired mode, so if you're after an additional degree of reliability (or even if the battery has just run dry and it needs a charge), you can keep typing as normal. That said, the charging circuit emits a barely noticeable high-pitched whine, which may or may not irritate you in the same way as a lurking mosquito that you can hear but not locate, and even Corsair doesn't quote the battery as running for longer than 15 hours, which isn't impressive.

We don't hate the K63. It's a practical, well-built, and neat-looking keyboard, with perfectly decent switches. It's wireless (a rarity in the mechanical game), and it even boasts full rollover and anti-ghosting. You can set up your own macros in software, and mess with the lights all you like. But it feels more like an interim attempt. If Corsair stays in the sector, its next iteration will surely blow this away. **–ALEX COX**

VERDICT 7

Corsair K63 Wireless Mechanical Gaming Keyboard

TYPING Heavy, substantial construction; good switches; wireless.

GRIPING Some signal dropouts; oddly splayed layout; short battery.

$110, www.corsair.com

SPECIFICATIONS

Switch Type	Cherry MX Red
Form Factor	Tenkeyless
Media Keys	Yes
Macro Keys	Software-defined
LEDs	Blue
N-Key Rollover	Full-key with anti-ghosting
Battery Life	15 hours (up to 75 without backlight)
Dimensions	6.8 x 14.4 x 1.6 inches
Warranty	Two years

Corsair Dark Core RGB SE

Wireless gaming and Qi charging at a knock-down price

IT'S BEEN THE BEST part of a decade now since Corsair first forayed into the peripherals market, and despite some excellent keyboard and headset offerings along the way, it's never truly cracked the gaming mouse. At least, not by the manufacturer's own mile-high standards. The reassuring build quality, masterful design, and luscious aesthetics of its cases never quite translates to mice, and although we can't fault the functionality or spec sheet of this Dark Core, it doesn't buck that trend either.

But let's start with the positives, because they're really worth shouting about. Somehow, the Dark Core RGB SE is positioned well below other manufacturers' wireless offerings in price, and it's not obvious where the costs have been cut. Far from it—the Dark Core can even boast to be the world's first Qi charging mouse, which means you can slap it on any charging pad to juice it up. It's not usable while you do so, however.

Other manufacturers locked the ecosystem with proprietary charging solutions, but Corsair's played a smart move using the increasingly ubiquitous Qi that you might already use to charge your mobile devices. And if you don't, there's always good old-fashioned USB charging. The wireless connection itself feels rock solid, too—no dropout, and no discernible latency. That alone is a pretty great feature set for $90.

There's also a swappable side panel included in the box, to accommodate different grip types, so if you like every digit floating around on the mouse, as with various R.A.T. models, you can make that happen by slapping on the other side panel. Those with more traditional palm and claw grips will prefer the default panel, but it's nice to have the option, isn't it?

And yes, of course it's RGB. Heaven forbid your palms should go unilluminated while you play. Corsair's CUE software will help you out with custom lighting, if that's your thing, otherwise you're treated to the usual whirling maelstrom of neon colors. What fun. Then there's the really important stuff: tracking. Fundamentally, the 16,000 dpi sensor produces smooth and responsive motion. It's up there with the best mice we've tested lately, wireless or otherwise.

That's the good. And it's a considerable amount to pile up in the "good" column. But there's also a lot we're not sold on here.

On a superficial level, we don't like the look. There are so many different surface types, buttons, curved and straight lines, and flashing colors all competing for your attention at once—you'd never guess it came from the same manufacturer that produces the most elegant, fuss-free cases in the business.

Some of those aesthetic problems—specifically the buttons and shapes—carry over into ergonomic issues. This simply isn't a particularly comfortable mouse under our hand, no matter what grip we adopt. It's bulky, and forces our fingers to rest right on the sharp seam between the right mouse button and the side panel. Your own experience will vary, of course, depending on the dimensions of your hand; we can only tell you about our encounters.

The button placement only seems to force our hand into a more awkward position, too. In order to really reach the thumb buttons, we have to force a pretty unnatural position, and this gets rather exhausting over time.

After a few hours, the advantages of wireless and Qi charging—not to mention a muscular 24-hour battery life—lose a bit of their sparkle under the force of the Dark Core's imperfect ergonomics. That's a huge shame, because Corsair has done brilliantly to position such a feature-rich mouse at this price point. We're waiting for the revised model to blow us away, but until then, we can only offer a qualified recommendation: Try it in your hand before hitting the "Buy" button. **–PHIL IWANIUK**

VERDICT **7**

Corsair Dark Void RGB SE

CORE STRENGTHS 24-hour battery life; Qi charging.

IN THE DARK Poor ergonomics; overly busy design.

$90, www.corsair.com

SPECIFICATIONS

Sensor Sensitivity	16,000 dpi
Sensor Model	PMW3367
Polling Rate	1,000Hz
Programmable Buttons	9
LEDs	4 zones
Battery Life	24 hours
Cable Length	6-foot braided USB charge cable
Weight	4.5oz

1More Spearhead VRX Gaming Headset

All-around sound

WE ARE NOT ONES to sneer at silly gimmicks, but—no, actually, we are. And we had a real serious sneer ready for the Spearhead VRX, which adds positional head tracking (labeled "Waves Nx") to the existing Spearhead VR formula. Had it come from a company with less gravitas than the surprisingly awesome 1More, perhaps that sneer would have stayed on our faces; maybe, had the gimmick not turned out to be a pretty neat feature that actually adds a decent new dimension to your gaming exploits, the grimace might not have turned into a smile. But we're grinning. Even outside of the VR realm, where you'll potentially struggle to wear these cans, given the wide-yet-narrow design of their upper band, the turn-your-head effect works perfectly, though it's only really apparent in front of your monitor if you're running a huge super-widescreen setup or you wobble your skull around habitually.

Waves Nx extends beyond positional tracking into this headset's integrated 7.1 simulation. That, too, is sweet, nimbly directing sound around your head on the horizontal axis, with only a slight deviation into weird echo, and a minor drop in quality from stereo. The software-EQable soundstage that backs it up is just joyous. It's not quite the exquisite and intricate mix of 1More's triple-driver cans, but this is far cheaper, and the 50mm graphene loudspeakers (which, we're told, use some kind of magnetic levitation) manage a rich experience. It's spritely on the high end, adequate in the middle, and as brutal as you like on the low—click the on-board volume control, and you can dial up the bass without poking around in the driver, and taking it all the way gives rise to seriously explosive vibration. Extreme bass does squash the rest of the frequencies, though.

Its sound might be on point, but 1More's design is about as mixed a bag as you'll find. The head band, topped with reasonably stiff metal and bottomed with an auto-adjusting wrapped band, which stretches in the center, is comfortable, but tends toward tight. The foam inside the earcups, given that tension, is far too soft, causing the speaker cap to press on the cartilage of more prominent ears. We found the slide-out light, a stiff tentacle that extends as far as your jaw, pretty cute, and initially presumed it was a mic. It's not. It's a tube that does nothing. The mic is hidden in a tiny dot on the other earpiece, and sounds predictably hollow and distant. RGB lighting around the rear of each earpiece and on the base of the head band is a quality touch, but whoever decided to also add sound-activated lighting to the not-actually-a-mic stalk either deserves a reward or a stiff kicking; it's utterly pointless, distracting in your peripheral vision, and seems cheap—but from a different perspective, it's damn cool.

We have other issues. Most of the more special features of the Spearhead VRX are (understandably) unavailable if it's plugged in via 3.5mm jack, but the micro-USB cable feels flimsy, and we wouldn't bet our lives on the resilience of its port. Environmental noise canceling is a nice feature, pulling outside sound from mics on either side of the headset, but we didn't find it made a huge difference, and when you're trapped in a headset as tight as this, there's little space for external noise anyway.

Let's put that aside. Is positional tracking a big enough selling point on its own? Probably not. As part of a predominantly well-built package, with great sound quality backing it up? That's a different matter. While there are some niggles to overlook, and while this isn't, as a headset, on the same lofty level as some hardware of a similar price, it's really a great headset on its own merits. And if the thing that your stream needs is a ludicrously lit microphone flashing as you speak? You're all sorted. **–ALEX COX**

VERDICT **8**

1More Spearhead VRX Gaming Headset

POSITIONAL Great sound quality; well-engineered band; nice lighting; head tracking works well.

DETESTABLE Mic needs work; over-tight construction; flimsy cable.

$200, http://usa.1more.com

SPECIFICATIONS

Driver Type	50mm maglev graphene
Impedance	32 ohms
Frequency Response	20Hz–20kHz
Design Style	Closed back
Microphone Type	ENC dual mic plus built-in mic
Connectivity	Micro-USB, 3.5mm jack
Weight	11.4oz
Cord Length	6.6 feet (USB), 4.3 feet (3.5mm jack)

Corsair Obsidian 500D

Hitting case pay dirt

IN A WORLD littered with aluminum boxes, it's nice to see one that stands out. It's not just another square black box. OK, the 500D does sorta follow that aesthetic, but that's what the Obsidian line-up is about.

The 500D's standout features are its subtly curved, black brushed aluminum panels, front and top. Fixed to the chassis, they aren't designed for easy removal, but that's not a problem. Along each side lie tempered glass windows—sitting on hinges, they're clean, crisp, and removable, and each features a curved brushed aluminum edge, melding into the front panel. And speaking of panels, let's dive into them, as they're one of the 500D's best design features.

There's a one-inch gap between the fan mounts in front and the panel itself. Running along each side of the case, from top to bottom, this allows for substantial airflow. Despite the fact the front panel isn't easily removable (there are screws that secure it in place, but they're a nightmare to get to), you can easily install a 360mm radiator or three 120mm fans via a removable front bracket held in place by two thumbscrews and a couple of notch cutouts. It's an intuitive design, which we've seen in a few cases, but what's really smart is how Corsair has utilized this in conjunction with a magnetic dust filter. Remove the front radiator bracket and the filter, and you're left with a massive rectangular cutout between the two. There's absolutely no excess metal in the way of airflow. The fan filter is one solid unit, too. With a very fine mesh, strong plastic frame, and an abundance of powerful magnets, it slides out easily, and sticks securely in place with minimal fuss.

Airflow is a little more restrictive in the roof, as it doesn't have the same one-inch clearance. To counter this, Corsair has milled out an array of triangular cutouts along the center of the plate. It's both aesthetically pleasing and an intuitive way to allow air to pass through. Either side of that, the panel is raised by around 0.25 inches in a smooth bend, to allow more air to pass through and out. It also features another radiator bracket, with cutouts and mounting points for up to a 280mm rad.

This is where things get a little funky. Both brackets, despite different mounting cutouts, are the same dimensions. You can swap them around, and have the 360mm in the roof and the 280mm at the front. Which begs the question, why not just include two 360mm brackets? We guess Corsair wants to avoid conflicts with multiple 360mm radiators, and is encouraging you to only install the specs it has in mind. The thing is, there's only a conflict if you use two relatively thick 360mm rads. If you fit a thick radiator in the front and a slim 360mm in the roof, there's minimal conflict, and room for fans, too.

On top of cooling potential, the interior is also stellar. There's a clean-looking, three-quarter, closed-off PSU cover, two 3.5-inch hard drive mounts in the rear, three 2.5-inch SSD sleds rear-mounted on the mobo tray, a cable management bar, including rubber grommets, a vertical PCIe GPU mount (but no cable), and a fairly beefy front I/O, including USB 3.1 Type C.

Couple all that with an aggressive $150 price point, and it's hard to pick fault with this mid-tower of perfection. The worst thing about the whole affair is the fact the cardboard box opens sideways. Seriously, that's our gripe: the box. **–ZAK STOREY**

VERDICT 9 KICK ASS!

Corsair Obsidian 500D

VOLCANIC Exceptional cooling design; versatile; super-clean aesthetic; aggressive price point.

GRAPHITE Cardboard box sucks.

$150, www.corsair.com

SPECIFICATIONS

Form Factor	Mid-tower
Motherboard Support	ATX, microATX, Mini-ITX
Colors Available	Black
Window Available	Only
3.5-Inch Support	2
2.5-Inch Support	3
Radiator Support	360mm front, 280mm roof, 120mm rear
Fan Support	3x 120mm front, 2x 140mm roof, 1x 120mm rear
Dimensions	9.2 x 20 x 19.8 inches
Graphics Card Clearance	14.6 inches
CPU Tower Clearance	6.7 inches
Weight	23.1lb

World quest bosses quickly turn into a swirl of numbers, nameplates, and player spells.

World of Warcraft: Battle for Azeroth

The world's most popular MMO goes back to basics

IT'S NOT OFTEN we look at game expansions, but when it comes to the juggernaut that is *World of Warcraft*, we made an exception. Why? Well, with so many games out there nowadays, it's rare that two of us here are playing the same title at the same time. And with a combined 27 years' worth of *WoW* experience between the two reviewers, we thought it would be worth sharing our views on Blizzard's latest blockbuster.

WoW is a genre-defining achievement. Surpassing the likes of *Everquest*, it reimagined what an MMO could be, making it more accessible to the mainstream. Over the years, it reached almost 13 million subscribers (at $10 a month). But it hasn't been without upset, with many a design decision or lackluster expansion reducing that number cataclysmically.

Battle for Azeroth (or *BFA*) is the seventh *WoW* expansion, and marks a return to the original premise of a world at war. Harking back to the conflicts in the original *Warcraft* strategy games, it looks to rekindle faction pride by pitting Horde and Alliance against each other after the world-scarring events of the last expac. With a redesign to how realms and world PvP works, it's a far more attractive proposition to spend time smashing enemy players while leveling than ever before. That said, before we delve into our experiences, it's worth covering what *BFA* offers. It takes players from level 110 to 120 (with a level boost to 110 included on purchase), there are two new continents (one for each faction), with three new zones each to level up through, ten new five-man dungeons, one new raid, and a ton of class, profession, and gameplay changes.

There are no new classes or races to play as; instead, there are Allied races. These essentially reskinned existing models provide cosmetic rewards to players looking for something fresh. However, each is locked behind a lengthy reputation grind, with some stuck behind rep grinds from the prior expansion. There are six currently—four from *Legion* (the last expansion) and two from *BFA's* endgame, with each faction receiving three apiece—and at least two more promised later in *BFA's* life cycle.

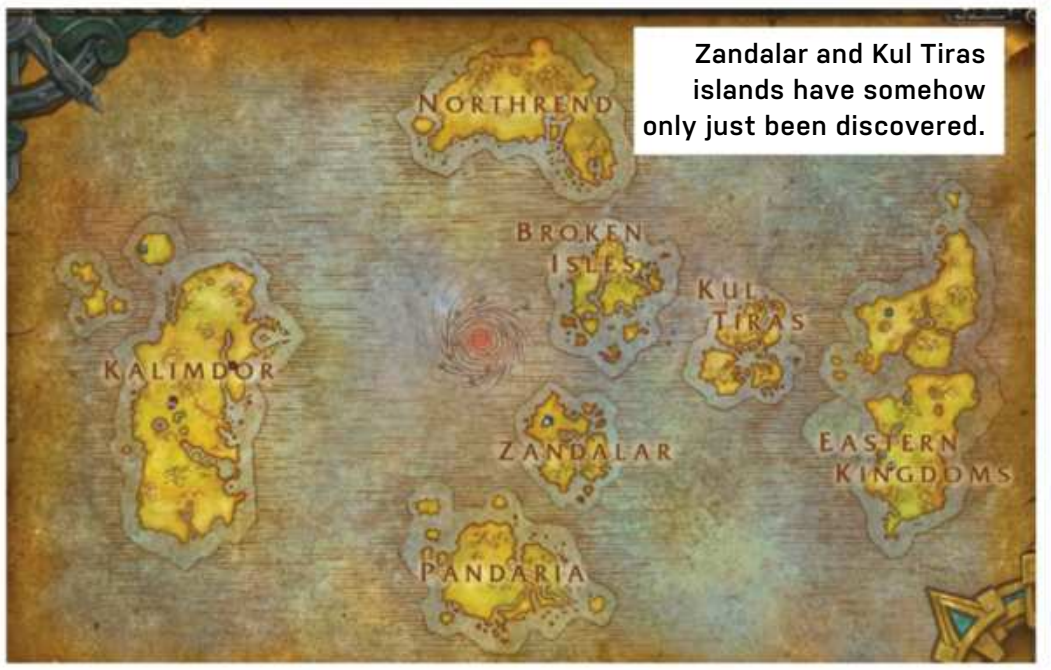
The majority of the action takes place on the lost islands of Kul Tiras and Zandalar, and on top of three-man island skirmishes (versus AI or other players) and Warfronts (think a bigger PvE battleground), provides players with two unique leveling experiences. Previous expansions saw the Horde and Alliance leveling through the same areas, fighting here and there, but generally getting on with business, trying to reach the level cap to fight the next big bad as quickly as possible. Here, each side gets their own island to level through, each made of three zones that you can do in any order. You do occasionally pop across to the opposing faction's island as part of your thematic war campaign, but it's only once you hit level 120, and the world quests kick in (providing Azerite power, reputation, gold, and equipment rewards), that you really see the other faction.

The Azerite Necklace is a new system integrated into the game following *Legion's* dynamic and ever-growing Artifact Weapon and Legendary item setup. It's a continually growing power source that provides a massive stat boost and access to additional gameplay traits on three pieces of armor that you acquire throughout your time in *BFA.* These traits range from the mundane increase stat X by amount Y when you cast a spell to survivability increases, item level improvements, and even playstyle-changing mechanics, although the latter is rarer. Despite being a nice addition, it's considered a dumbed-down, duller variant of *Legion's* Legendary and Artifact system.

As for endgame content, aside from world quests and PvP, there's a healthy selection of dungeons to battle through and, of course, the first raid tier, Uldir, a Titan-themed laboratory. For dungeons,

Borealis is a beautifully realized, sprawling town that takes some getting used to.

Snake people and lightning—what could possibly go wrong?



Zandalar and Kul Tiras islands have somehow only just been discovered.

Uldir, the first raid instance, makes quite an impression on first sight.

there are three difficulties: Normal, from 110 onward; Heroic, once you hit 120 and a certain gear level; then Mythic, which is even more difficult, but provides better items. Mythic+ opens up at the same time as the initial raid launch, scaling from Mythic 1–20, and provides even greater challenges and better loot.

HOCUS FOCUS

One difference this time around is that there's no obvious big personification of evil to defeat. For the Horde, there's a story involving the trolls that inhabit the island on which you arrive, with hints of bigger things that are a threat to Azeroth, but it isn't as laser-focused as previous expansions. For the Alliance, it's all about reuniting the island's three main houses. There's everything from Wiccan magic to tide-controlling sages, pirates, and more. However, there's a lack of urgency to your crusade, and although we're sure that big bad will arrive eventually, there's nothing too immediately threatening, with even the grand scale of the faction war being somewhat sidelined. There are hints that an old god may make an appearance further down the line, but for the time being, zilch.

How does this all play out? Really, really well. Blizzard knows what it's doing, and while there have been a few missteps here and there, this still holds true. *WoW* is a massive world, and there's plenty to do at any given moment. Whether you want to run dungeons, experience older raids, do world quests, enjoy some PvP, battle pets, or simply explore, there's always lots more to do than you've got time for. There's a revamped profession system to sink your teeth into, reputation to be gained, and enough challenges to task even the most fervent of achievement hunters.

It also looks great. Sure, it can't compete with the likes of *Witcher 3* or the latest raytraced hype trains, but its scope and vision mean there are times when you'll just stop to take in an incredible vista, or marvel at the scale of the huge city that surrounds you. The massive ziggurat at the heart of the Troll kingdom is a case in point, and while it isn't easy to navigate, it does throw up some beautiful views. It'll be awesome when we can finally start flying around again, but as ever with a new expansion, your flying mounts are suction-cupped to the ground, at least for the time being.

Battle for Azeroth is a worthy addition to a game that keeps tweaking itself to stay relevant and challenging. It's hard to tell whether this expansion will be as fondly remembered as the best, but as the overall goal emerges, it has a chance. It would have been preferable for the endgame to be clearer, and to have more areas to explore, but at least you can switch sides, and experience the Horde and Alliance stories first-hand. **–ALAN DEXTER & ZAK STOREY**

VERDICT **8**

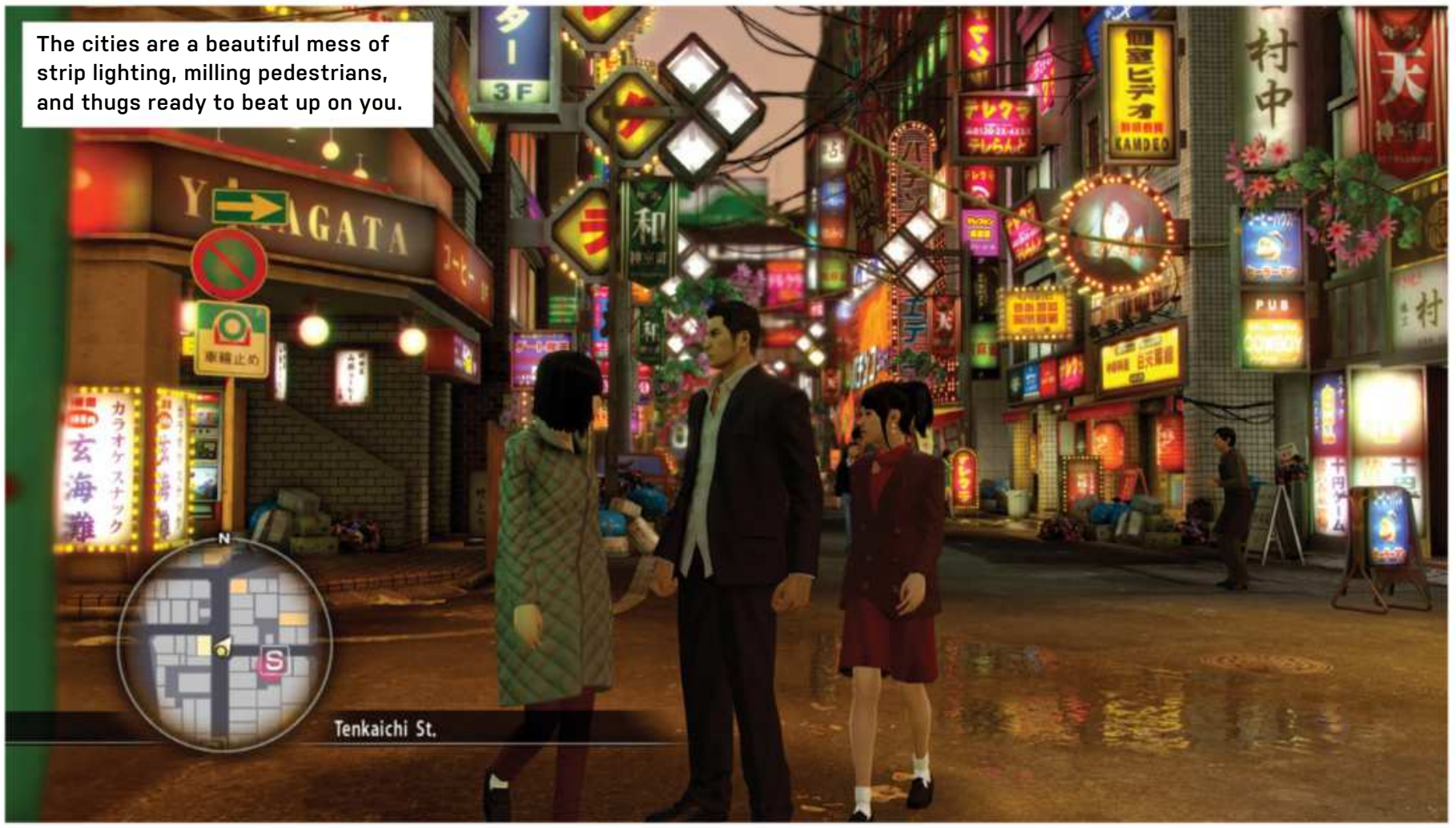
World of Warcraft: Battle for Azeroth

LEGENDARY Beautifully realized new continents; varied dungeons; island expeditions and world PvP work well.

COMMON Limited leveling zones; no obvious overall goal.

RECOMMENDED SPECS i7-4770/FX-8310; 8GB RAM; GTX 960/R9 280.

$50, www.battle.net, ESRB: T



The cities are a beautiful mess of strip lighting, milling pedestrians, and thugs ready to beat up on you.

Yakuza 0

Kuso, it feels good to be a gangster

THE SIXTH GAME in a previously PlayStation-exclusive series getting a Windows release when none of the earlier games did may seem like an oddity, but *Yakuza 0* was designed as a jumping-on point for those who hadn't played before, so is the perfect ambassador for Sega's mob epic.

The name gives it away: Lead characters Kiryu and Majima are Yakuza, Japanese gangsters. Kiryu is the series's protagonist, while Majima has been a supporting character until now. And while Kiryu is often content to let his fists do the talking, allowing a player to project themselves into his sharp suit, Majima is a flamboyant madman, his personality strongly etched from the moment you meet him.

The plot is a duffer—a dispute over real estate that turns out to be a conspiracy—but exists only to give the characters something to do, which means fighting, and keep them moving around, which also means fighting, as gangs of hoodlums attack from almost every street corner. These fights are over quickly, and you earn money from giving goons a beating, so they're little more than an annoyance. You can avoid them by taking a taxi, but then you'd miss out on the city.

Yakuza 0's two hubs, fictionalized versions of Osaka and Tokyo's entertainment districts, are swirls of bright lights and none-too-bright gangsters. They're always busy, there's always something to do, and while it may feel like an open-world game, it's not. You can run across the map in a few minutes, but every moment of your time there is accounted for. Stop off on the way and you can sing karaoke, dance, practice baseball, play Sega arcade games, bet on fights, play cards, and find myriad other ways to while away the time. You're never directionless; a marker is always calling you to a nearby building, where you know you'll find violence—and possibly sex.

After an intro that contains slightly more breast-fondling than we're used to, the game goes on to develop a questionable view of women, displaying them solely as objects to entertain men, or items to collect. It's hugely noticeable in 2018, and as rooted in the past as the game's 1980s setting, which also informs its attitude to the collection of money, and mars an otherwise exceptionally enjoyable game.

The save system is also old-fashioned, although not unusual in Japanese games. Rather than saving constantly, or at checkpoints, you must stop at phone boxes. Forget, and you have to repeat sections. We also had to repeat a section after a bug saw items in our inventory turn into fish—which proved to be a one-off, and an issue with a patch causing crashes should have been resolved by the time you read this.

As a game that originated on PS3, you may not expect too much graphical fidelity from *Yakuza 0*, and it runs on very low specs, but it scales to 4K well, and refresh rates up to 240Hz are supported. It knows what it's good at—hot nights in the city, lit by flashing signs, and with crowds to dodge through—and is able to concentrate on these, narrowing the amount of space that needs rendering, and throwing up a depth-of-field filter to make you forget the rest.

Yakuza 0 is a good-looking game, which digs more enjoyment out of real estate than we thought possible, but with some questionable attitudes. Despite this, it's ridiculously entertaining, and we hope the rest of the series follows soon. **–IAN EVENDEN**

VERDICT 9

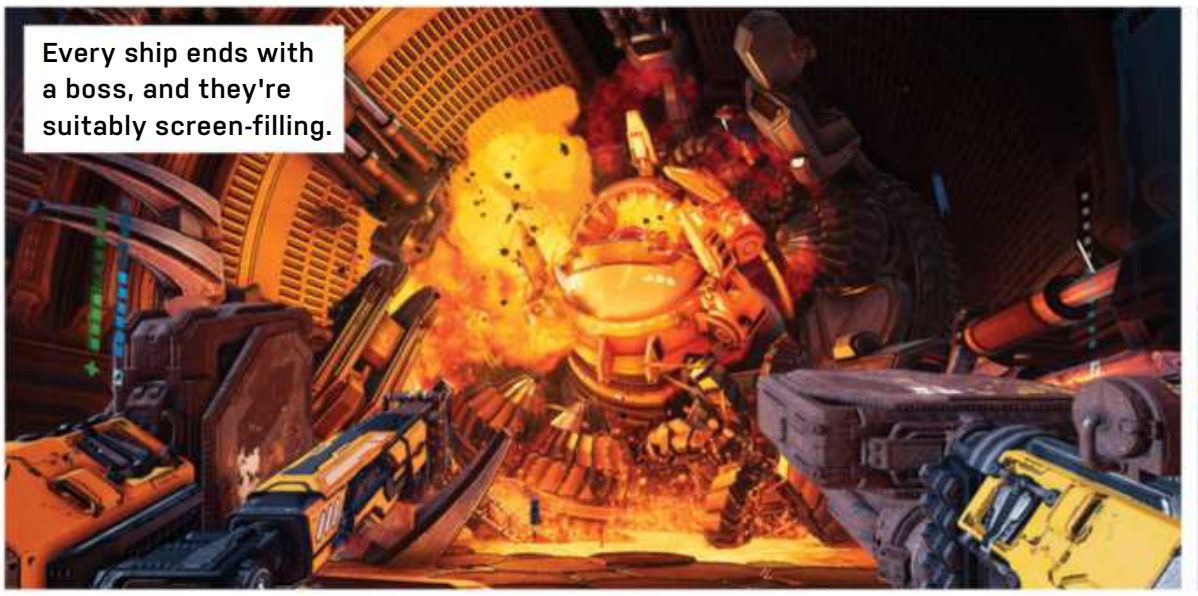
Yakuza 0

GANGSTER Deep fighting system; many side activities; hugely entertaining.

PRANKSTER Slightly annoying save system; very low opinion of women.

RECOMMENDED SPECS i5/FX-6300; 4GB RAM; GTX 560/Radeon HD 6870.

$20, www.yakuza.sega.com/yakuza0, ESRB: M


Every ship ends with a boss, and they're suitably screen-filling.

Weapons are a mix of energy and projectile; flamethrowers are a particular highlight.

Teetering on the edge a level lets you scope it out, enemy-free.

Workbenches let you admire your gun creations.

Mothergunship

Just what Neo wanted, but far, far more

BEING BIG AND DUMB never did us any harm, but for some reason it's looked down upon. Not here, though. *Mothergunship* does not set out to be subtle, and it does not attempt to be serious. From the scenery-chewing Colonel to the way your starship AI gets infected with pop-up ads, there's a deft comedic streak behind all the shooting.

Ah yes, the shooting. There's a lot of it. *Mothergunship* is a bit like the original *Doom,* as hordes of bad guys rush toward you as you enter a room, and you open fire until they're all gone. There are no tense duels as you switch between cover points, no last-second headshots, and no way of sneaking through undetected. Levels are also randomly generated, so if you die and try again, the rooms aren't the same.

Neither is your loadout. You're given a choice of basic weapon parts as you begin, and bolt them together at the workbench helpfully located at the point you breach the alien invasion ship. Guns come in three stages: connectors, which connect; barrels, which shoot; and endcaps, which modify stats. There's only one rule: Barrels must point away from you. As you blast your way through the alien robots, you amass coins, which can be spent at convenient shops on more gun parts.

Each arm of your power armor has a limited amount of energy that can power anything. Each gun barrel shoots something different, at a different rate, and uses a different amount of energy. You can strap three barrels together if you have the right connector, creating a rocket-launcher-flamethrower-shotgun hybrid, but after a few seconds of hugely destructive use, it takes a long time to reload.

When it's good, it's very good—getting into the zone of gunning down enemy flyers, turrets, and weird dog-things with a long-range weapon on one arm and something with close-up punch on the other. Enemy shells are easily seen and slow moving, so can be dodged even if you're in the air after being propelled by a jump pad. Running a final lap of the room to collect coins before moving into the shop and tooling up, ready for a boss encounter, feels like a game running at peak levels of efficiency.

When it falls down, it's largely due to the procedural generation, which has had its "random" slider turned up a little too high. You never know how many coins an enemy is going to drop, and shops that seem plentiful at first can become scarce. You'll settle on favorite gun parts, banking them at the end of a mission, so you can access them later. Die, and you resurrect on your ship without anything you've collected, and this disincentivizes experimentation.

As it is, it's a perfectly serviceable release, but a note at the end suggests more is planned, including a co-op mode that should be in place when you read this. It's a little raw at the moment, but given patches and time, should come together like the machine-gun-grenade-lightning-launcher of your dreams. **–IAN EVENDEN**

VERDICT 8

Mothergunship

SHOOTY Immense fun; hugely creative; lots to blast; many guns to blast with.

FRUITY Gets a little samey, especially in the visuals; favorite guns quickly appear.

RECOMMENDED SPECS i5-6600K or Ryzen 5 1600; 8GB RAM; GTX 1060 3GB or Radeon RX 580 4GB.

$25, www.mothergunship.com, ESRB: T

LAB NOTES

BO MOORE, HARDWARE LEAD

The 4K HDR Conspiracy

Wild speculation about why 144Hz 4K HDR screens took so long

I RECENTLY, FINALLY, got Asus and Acer's new high-end gaming monitors, the Acer X27 and Asus PG27UQ, for testing. The new cream of the crop, these beauties pack in every feature under the sun: 4K resolution, 144Hz refresh rate, HDR, and G-Sync. They were first teased at last year's CES, officially announced in April of the same year, and were expected to show up sometime in the fall. Then, in August 2017, it was announced that they'd been delayed until Q1 2018, which came and went with nary a new monitor in sight. The next target was July. Finally, they showed up in August, more than a year and a half later than that initial CES tease.

So, what took so long? Considering that both companies saw the same delays, we can assume it was some kind of hold-up at the panel manufacturing level. But I have another theory, a crazy conspiracy theory: I think the monitors have been ready all along. They looked ready back in 2017, and they sure looked ready when I saw them at CES earlier this year. I think Asus and Acer were just waiting for Nvidia to announce its next-gen GPUs.

Think about it like this: In early 2017, the high end of the GPU landscape was the GTX 1080 Ti. While that mega-powerful card absolutely crushes 1080p and 1440p, it generally topped out at around 60fps for most games at 4K. In that case, what use would anyone have for the zippy 144Hz refresh rate of the X27 and the PG27UQ?

No, I think Asus and Acer recognized that their new high-end monitors were too good for the current market, so they waited. And now that Nvidia's RTX 2080 and 2080 Ti are launching, sure enough, the monitors are on store shelves.

What if Asus and Acer's long-delayed high-end gaming monitors have been ready all along?

JARRED WALTON

Senior Editor

A lot is going on in the tech world, with Intel's ninth-gen CPUs slated to arrive soon, along with new Z390 mobos. But the real excitement is Nvidia's Turing architecture and GeForce RTX 20-series GPUs. In preparation for the new cards, it was time to revisit my GPU testbed—because when you're about to test what is likely to be the fastest graphics cards ever, you don't want to limit performance by using an older CPU.

My previous testbed used an overclocked Core i7-5930K, which still holds up, but I've moved to a Core i7-8700K overclocked to 5.0GHz. If you're wondering why not Core i9, the reason is simple: For gaming and graphics, Coffee Lake is almost universally faster than Skylake-X. That's mostly thanks to higher clock speeds, faster L2/L3 cache, and architectural differences, such as the ring bus topology instead of mesh.

This change does have one major drawback: I need to retest every graphics card on the new system. That would be a deal breaker, but with all the game patches and driver updates, it's often necessary to go back and retest everything regardless. One thing that we can't yet evaluate is how Turing's ray-tracing and AI capabilities impact performance and graphics. That's because we're waiting for the games and Microsoft's DirectX Ray Tracing API, both of which should arrive next month. Stay tuned.

Editors' Picks:
Digital Discoveries

Zak Storey, deputy editor, and Alan Dexter, executive editor, reveal the tech that's been spicing up their lives

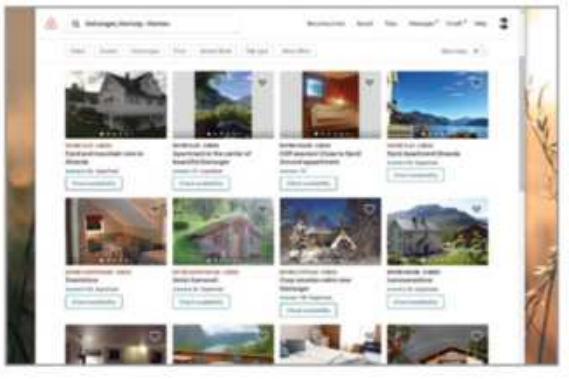
AIRBNB

Last issue, I mentioned how I'd given up *WoW* and instead had decided to spend my time boning up on the Norwegian language. The reason is that I'm third-generation Norwegian on my father's side, and the more research I do into my family, and into Scandinavian history, culture, and mythos, the more I've found myself drawn to the place, and the more the desire to go there builds. So, for next year's birthday, I figured, hell, why not spend some time over there?

It's rather an epic trip, with multiple flights needed to get me and the fiancée to Bergen, then a rental car to drive us the remaining eight hours to our cozy fjord-facing home in Geiranger, but in my eyes, I can't imagine a better way to cap off October.

It isn't cheap, for sure, but what has been affordable is the accommodation. Airbnb is my site of choice for holiday accommodation; the wide range of properties available across the globe, from B&Bs to private rooms, full houses, and lodges, at affordable prices, is awesome. I've yet to have a bad experience. So, if you're planning on spending a short stint somewhere, and aren't interested in shelling out on sky-high hotel costs, give Airbnb a look first.

$Free, www.airbnb.com



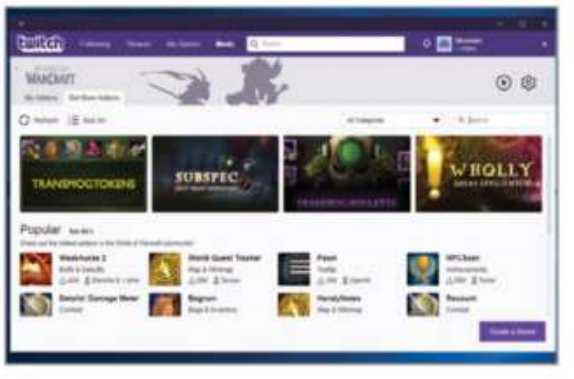
TWITCH APP

World of Warcraft relies on add-ons to allow users to personalize the way the game looks and acts. While not essential, these add-ons either fill gaps in the interface (such as tracking damage), or just make life easier (PetTracker is great if you're into the game's *Pokémon*-inspired pet battles). There's a couple of problems with these add-ons, though: There are now so many, that discovering the right ones for you is a challenge in itself, while keeping them all up to date isn't easy either.

Curse stepped into the breach, and pretty much became the go-to site for sorting out add-ons for not just *WoW,* but plenty of other games, too. Twitch bought out Curse a while ago, and integrated add-on management into its app. Click the "Mods" tab, and you're presented with a list of supported games, including the behemoth that is *WoW.*

There's an incredible number of add-ons available, but click "Get More Addons" and you can list them by the most popular, and set what categories you're interested in (PvP, Professions, Boss Encounters, and so on). Keeping your add-ons up to date is but a click away, and if you play on more than one machine, you can sync your selection to the cloud, so it's the same on each.

$Free, www.twitch.tv



Corsair MM1000

I'VE LONG RAILED against ridiculous mouse pads. Being a connoisseur, I like a hard mat that's durable, smooth, easy to clean, and preferably not aluminum (bad experiences). That's why the mat I'm using today is over three years old—and still looks brand new. It's all about that old adage Poppa Storey used to say to me: "Keep it simple, stupid." And that's exactly what a mouse mat should be: simple. That doesn't mean dumb, it means it does what it's meant to do, in such a manner that it doesn't need any additional thrills.

That's not something mainstream peripheral manufacturers seem to be able to grasp. From the first LED-touting RGB monstrosity, I've hammered these things into the dirt, reviewing three—from Razer, Corsair, and SteelSeries—and scoring them 3, 4, and 6 respectively.

So, what's so special about this one? Well, the biggy is the integrated Qi charging pad in the top-right corner. Plop a wireless mouse on it to charge overnight, or a phone mid-gaming session, and you're on to a winner. Logitech recently did something similar with an entire pad that acts as a charging tray, but the bigger these things are, the less efficient they become, and I'm not convinced I want to keep my hand above a giant electricity-generating magnetic field like that for eight hours a day. Corsair also includes a micro-USB dongle (with adapters for Lightning and USB C), which can charge any device you connect to it wirelessly. Another plus is the fact that RGB is nowhere to be seen. But it's still a lot of money. **–ZS**

$70, www.corsair.com

LETTERS

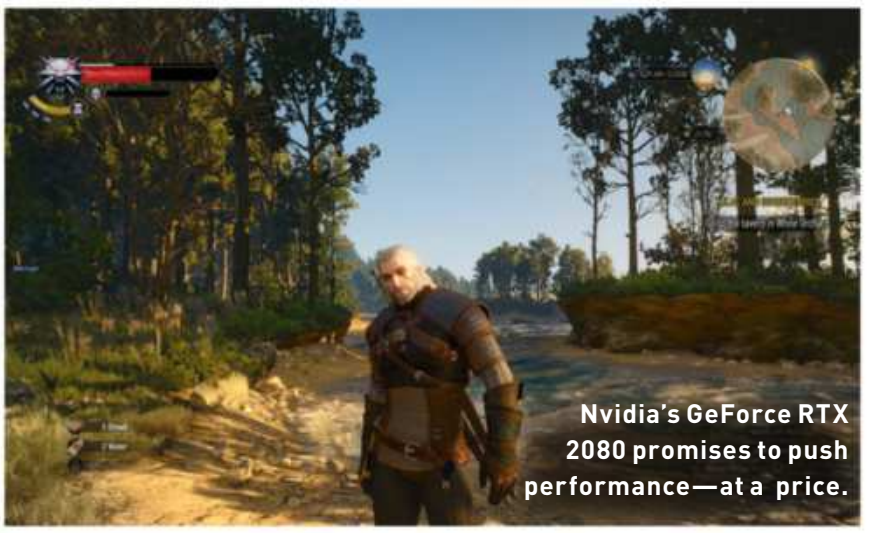
WE TACKLE TOUGH READER QUESTIONS ON...

> Future Formats
> Intrepid Explorer
> 4K Gaming Goodness

Lies, Damn Lies, & Stats

I remember when everyone said that typewriters were supposed to put an end to handwriting. Now, no one knows what a typewriter is. Fax machines were declared dead many years ago, but they're still used by many businesses. That's when I gave up on futurist ideals. I prefer physical media—video games, movies, and TV—for the love of the sound, which digital media audio can't compete with. Great editorial last issue, but where futurists always mess up is in taking the side of the consumed (product) instead of consumers (society). Numbers are just numbers in the end. **–Randy Williams**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS:
Your point is sound, and the resurgence in vinyl records proves that there's space for all kinds of media in this world. My point was that if you're building a media center to take you into the next decade, the general theme has moved away from supporting the myriad of media that has traditionally defined such a machine, to one that is focused on streaming. Of course, if you want your own media center to excel at playing Blu-rays, DVDs, and CDs, adding an optical drive and using a case that supports it is the obvious way to go, and it'll be good at streaming,too. We've penciled in a build for a few issues' time that checks these boxes as well.



Nvidia's GeForce RTX 2080 promises to push performance—at a price.

Color Correction

I love your magazine; it is the best information I can get on what's new, what works, and what will enhance my system. I worked for IBM from 1970 (before you were born), on everything it made. Even typewriters.

Before you go to print again, have a 74-year-old with poor eyesight proof the articles! In the August 2018 issue, on page 30, there are purple web addresses on a purple backdrop. It looks pretty—to a 20–30-year-old with 20/20 vision, but not to all your readers, like this old man. I had to have my neighbor read me the website information. Please see it through my eyes!

–Jeff Goodstein

ART EDITOR FRASER MCDERMOTT RESPONDS:
Our apologies, Jeff. Sometimes, the on-screen representation is brighter than it prints—not an excuse, just an explanation. We do strive to stop this happening, but sometimes errors slip through. Going forward, we have some legibility improvements planned for next issue, so watch this space.

Audio Editing

In the article "Turn On, Tune Up, Rock Out" *[September 2018 issue]*, on page 39, Phil Iwaniuk says more than once, and excitedly too, that Reaper recording software is free. It most definitely is not. The trial mode is uncrippled, however, and never times out.

From www.reaper.fm/purchase.php: "A new license includes free upgrades through Reaper version 6.99. There is only one version of Reaper. The license price depends on how you use it. $60: discounted license. $225: commercial license.

"You may use the discounted license if: You are an individual, and Reaper is only for your personal use, or you are an individual or business using Reaper commercially, and yearly gross revenue does not exceed USD $20,000, or you are an educational or non-profit organization."

–Jack Huggins

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: Thanks for the clarification on this. Yes, while the trial version is uncrippled, and can be used as though it's free,

↘ submit your questions to: comments@maximumpc.com

when a piece of software is so well maintained and offers such great value for money, we should support the developer. $60 really isn't a lot to ask for such a powerful piece of software.

Exploring Solutions

I'm running Windows 8.1 (with Classic Shell), and more than one recent update from Redmond has broken File Explorer. I caught the first one (4338815) and restored, but there were more updates that caused the same havoc, and I was not able to restore from them. What happened is that after the update, I was no longer able to open a folder with a double-click. I could right-click and select "Open," but a double-click gives this message:

"This file does not have a program associated with it for performing this action. Please install a program or, if one is already installed, create an association in the Default Programs control panel."

I went looking for a way to fix this, and found that lots of people have the same problem, and there's a number of solutions to try. None of them worked for me.

I was close to reinstalling Windows when I stumbled across Explorer++, a File Explorer alternative. I tried it, liked it, and one of the options is to "Replace Explorer for all folders." I did, and problem solved. Don't the folks in Redmond test these updates, or is this intentional? (I am in no way affiliated with Explorer++, aside from being a user.)

–Steve G

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: I was tempted to ask you why you were still running Windows 8.1, but given your experiences, I can completely understand why you haven't jumped on to the forced updates of Windows 10. As for your move to Explorer++, it may not be a perfect solution, but it's a working fix to a problem that shouldn't exist in the first place, and for that alone, it's certainly one that's worth passing on to other readers, in case they're experiencing similar problems.

[NOW ONLINE]

WHAT MOUSE DPI DO I REALLY NEED FOR FIRST-PERSON SHOOTER GAMING?

These days, the best gaming mice come packed with so many buttons and features, that shopping for a new one can be overwhelming. Things like ergonomics, button placement, and even RGB lighting all need to be considered. There's also the matter of DPI, a feature that is often prominently displayed on packaging and in product listings. But you might find yourself still wondering: What DPI do I really need?

DPI stands for "dots per linear inch," and is a measure of how many pixels the cursor moves per inch that the actual mouse moves. Other names for DPI are "counts per inch" (CPI) and "mickeys per second," the latter being an older term that isn't used much anymore. No matter what it's called, it all boils down to one thing: mouse sensitivity.

Read the full article at https://bit.ly/2Of7ugE

4K Streaming Machine

I am a videophile and audiophile, who loves gaming with his PC hooked up via HDMI to his living-room home theater setup. My dream, however, is to build a dedicated home cinema with a Dolby Atmos/DTS C audio setup, and a 4K projector displaying on a 160-inch screen. Naturally, your "$1,400 Media Center" cover story intrigued me.

The idea is to, say, play something like *The Witcher 3* (with all settings maxed out) at 60fps (unless higher frame rate is achievable) in 4K. However, although your HTPC build is suitable for 4K streaming, from your benchmarks, it seems more at home with 1080p on the gaming side.

It occurred to me that perhaps I should modify your HTPC, based on the Turbo build. However, in the letters section of the same issue, Zak Storey states that you recommend the Turbo build not necessarily as a gaming-specific machine, but more as a pro workstation, designed to maximize your performance in professional workloads, as well as being a "hotshot at any task you throw at it." So what HTPC build would you recommend for someone who wants to game at 4K/60fps on a 160-inch screen, while sitting 11.832 feet away?

Also, is there any word on whether there will be a projector equivalent of the Nvidia Big Format Gaming Displays? **–JP Grajales**

DEPUTY EDITOR ZAK STOREY RESPONDS: Hmm, that's a good question, and it goes back to why we love PC systems to begin with. The customization options available—to make them either a jack of all trades, or specialized in one particular field—are almost endless. As to what you're after, although it's tricky to achieve, it's certainly not impossible.

You can see what I would generally recommend for a 4K HTPC at https://pcpartpicker.com/list/mMPNsZ. There's a few things to note, though: We haven't actually built this machine; this is more of a quick plan, looking at case spec and size. Also, bear in mind that, on the whole, the Shift X is a very tight case to build in, and as such, it does present some challenges during the process.

As for the hardware, a six-core processor should be more than enough for most 4K gaming. Combine that with a 120mm AIO (which you'd mount in the bottom), and it'll be cool and quiet, too. Graphics could be tricky; a GTX 1080 Ti does hold its own at 4K fairly well, but you do need to be a little wary of some titles being somewhat more aggressive (*Witcher 3* is a good example, especially with high fidelity and LOD mods installed). Nvidia's 2080 series may be a better solution, but wait for benchmarks to be sure. Storage-wise, it's really up to you, but I'd recommend dual M.2 drives. You can mount either two 2.5-inch drives, or a single 3.5-inch drive, but it's a little tricky, and the Strix H370-I recommended does support that combo of a PCIe M.2 SSD alongside a SATA M.2 as well.

Unfortunately, we haven't heard anything with regard to Big Format Gaming Projectors just yet, but we'll let you know if anything comes up.

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THE BUILDS

BUDGET

INGREDIENTS

PART		PRICE
Case	BitFenix Nova TG	$50
PSU	450W Corsair CX450	$45
Mobo	ASRock AB320M-HDV	$50
CPU	AMD Ryzen 3 1200 NEW	$160
GPU	Gigabyte GeForce GTX 1050 2GB NEW	$140
RAM	8GB (2x 4GB) Team T-Force Dark @ 3,000MT/s	$80
SSD	120GB Kingston A400 120GB 2.5 SSD	$31
HDD	1TB Seagate BarraCuda ST1000DM010 HDD NEW	$45
OS	Ubuntu Desktop Linux 18.04 LTS 64-bit	$16

Approximate Price: $617

WE'D SETTLED ON the Ryzen 5 2400G as our processor of choice for the budget build for quite some time. If you're after a standard rig that can have a fair shot at the old vidya games, while doing basic workloads, the G's still ya boy. But we're not ones to rest on our laurels, so we've swapped it out for something a little more exotic. As GPU prices are continuing to plummet, GTX 1050s are now hitting that sub-$140 price point. They don't offer the same impressive price-to-performance ratio as the likes of the GTX 1060 (and we always recommend you stump up for that if you can), but they're still pretty impressive nonetheless. We're talking at least 40fps in most AAA titles. To go with that, we've picked a Ryzen 3 1200. Although a little long in the tooth, its 16 PCIe lanes, versus the 2400G's eight, make it a better performer with a dedicated GPU. And with a solid four cores, it beats the competition at the same price, too.

MID-RANGE

INGREDIENTS

PART		PRICE
Case	Fractal Design Meshify C	$90
PSU	550W EVGA SuperNOVA 550 G3 80+ Gold	$73
Mobo	Asus ROG Strix B450-F Gaming	$130
CPU	AMD Ryzen 7 2700 NEW	$290
Cooler	Corsair Hydro H100i Pro 240mm RGB AIO NEW	$120
GPU	Zotac GeForce GTX 1070 Ti NEW	$400
RAM	16GB (2x 8GB) G.Skill Aegis 3,000MT/s NEW	$135
SSD	250GB Samsung 970 Evo M.2 PCIe SSD	$88
HDD	1TB Seagate BarraCuda ST1000DM010 HDD NEW	$45
OS	Windows 10 Home 64-bit OEM	$100

Approximate Price: $1,471

WE'RE REWORKING WHERE our mid-range sits, to try to position it between our 1080p and 1440p zero-point builds, price-wise. At least initially—once this issue's over, we'll revert to type, and inevitably continue to shift the pricing around to try to get the spec as cheap as humanly possible (not that we haven't done so already). So why the big upheaval? Well, it all falls down to those GPUs, and trying to find a nice balance between price and performance. The GTX 1070 Ti, despite being somewhat of a mixed-bag GPU, is a fairly respectable card. It performs almost as well as a GTX 1080. Coupled with a solid processor, the Ryzen 7 2700, our overclocking processor of choice, and a decent all-in-one cooler, and what you're left with is an insanely cost-effective, 1440p gaming machine. In fact, looking at the spec, it's not too dissimilar from the "Build It" we did this very issue. The only real difference being the storage and motherboard. Neat, huh?

UPGRADE OF THE MONTH

ENERMAX LIQTECH TR4 II

A cooler? For "Upgrade of the Month?" Are you mad, *Maximum PC?* Probably. But hear us out: This thing is darn impressive. We were apprehensive about using this bad boy at first, but after spending some time with it, we can honestly say it's one of the better AIOs we've had the pleasure of using with Threadripper. Whether that's because we have it set up with quad-Noctua NF-F12s in push-pull, because the CPU block covers 100 percent of the IHS, or because it's simple and easy to install, it's just really good. And finding a cooler that can take on a 16-core processor, and have it overclocked to 4.3GHz, nearly hitting that silicon limit, across all those cores, without reaching higher than 82 C, is a plus in our book.

Even the radiator looks stylish, and it comes with a two-year parts and labor warranty. OK, we'll stop gushing about it now, but seriously, if Threadripper is your jam, try giving this beauty a shot. At least for anything at or under 16 cores.

$140, www.enermax.com

OH BOY, that's a $39 saving over last issue's turbo build, and there's a whole ton of changes that have gone into it, too. So, why the big change-up? Well, it all starts with our Intel processor of choice, the Core i9-7900X. It's the Intel processor to go for right now: 10 cores, 20 threads, high clock speed, solid performance. Delid it, and you've got yourself a pretty chilly processor, too. Thing is, its price jumped all the way from $895 to $1,100. Yup, that's a no-go for us, as it's no longer competitive. The solution? Well, because Threadripper+ is now readily available, and pretty comfortable in both games and extreme workloads, we're happy to suggest it again over the 7900X.

Single-core performance is up, memory latency down, and overall clock speed increased. This does mean we've had to swap the mobo out (annoyingly for one that's $120 more), but we've leveraged costs elsewhere, opting for the same cooler we were given to test the 2950X, a new memory kit at a higher frequency than last issue, for less cash, and a somewhat more substantial graphics card.

Storage has come down a touch, too, so overall we're better off, ironically, and there's an additional 6 cores and 12 threads to play with, too. Why no RTX 2080? Well, to be honest, we're just not willing to recommend a GPU that effectively won't provide any more performance, for $130 more, on the pretense that some games might have slightly better reflections at some point in the future.

For more of our component recommendations, visit www.maximumpc.com/best-of-the-best

INGREDIENTS

PART			PRICE
Case	NZXT H700i		$173
PSU	Corsair RM750X Modular Gold		$110
Mobo	Asus Prime X399-A	NEW	$300
CPU	AMD Threadripper 2950X	NEW	$899
Cooler	Enermax Liqtech TR4 II 240mm RGB	NEW	$140
GPU	MSI GeForce GTX 1080 Ti ARMOR 11GB		$675
RAM	32GB (4x 8GB) G.Skill TridentZ 3200	NEW	$316
SSD	512GB Samsung 970 Pro M.2 NVMe		$200
HDD	2x 2TB Seagate BarraCuda ST2000DM006		$120
OS	Windows 10 Home 64-bit OEM		$100

Approximate Price: $3,033

Maximum PC (ISSN 1522-4279) is published 13 times a year, monthly plus a Spring issue following the March issue, by Future US, Inc., 11 West 42nd Street, 15th Floor, New York, NY 10036, USA. Website: www.futureus.com. Periodicals postage paid in San Bruno, CA, and at additional mailing offices. Newsstand distribution is handled by Curtis Circulation Company. Basic subscription rates: one year (13 issues) US: $24; Canada: US$40; Foreign: US$40. Canadian and foreign orders must be prepaid. Canadian price includes postage and GST (GST #R128220688). PMA #40612608. Subscriptions do not include newsstand specials. POSTMASTER: Send changes of address to *Maximum PC*, PO Box 5852, Harlan, IA 51593-1352. Future US, Inc. also publishes *Mac|Life*, and *PC Gamer*. Entire contents copyright 2018, Future US, Inc. All rights reserved. Reproduction in whole or in part is prohibited. Future US, Inc. is not affiliated with the companies or products covered in *Maximum PC*. Reproduction on the Internet of the articles and pictures in this magazine is illegal without the prior written consent of *Maximum PC*. Products named in the pages of *Maximum PC* are trademarks of their respective companies. PRODUCED IN THE UNITED STATES OF AMERICA.

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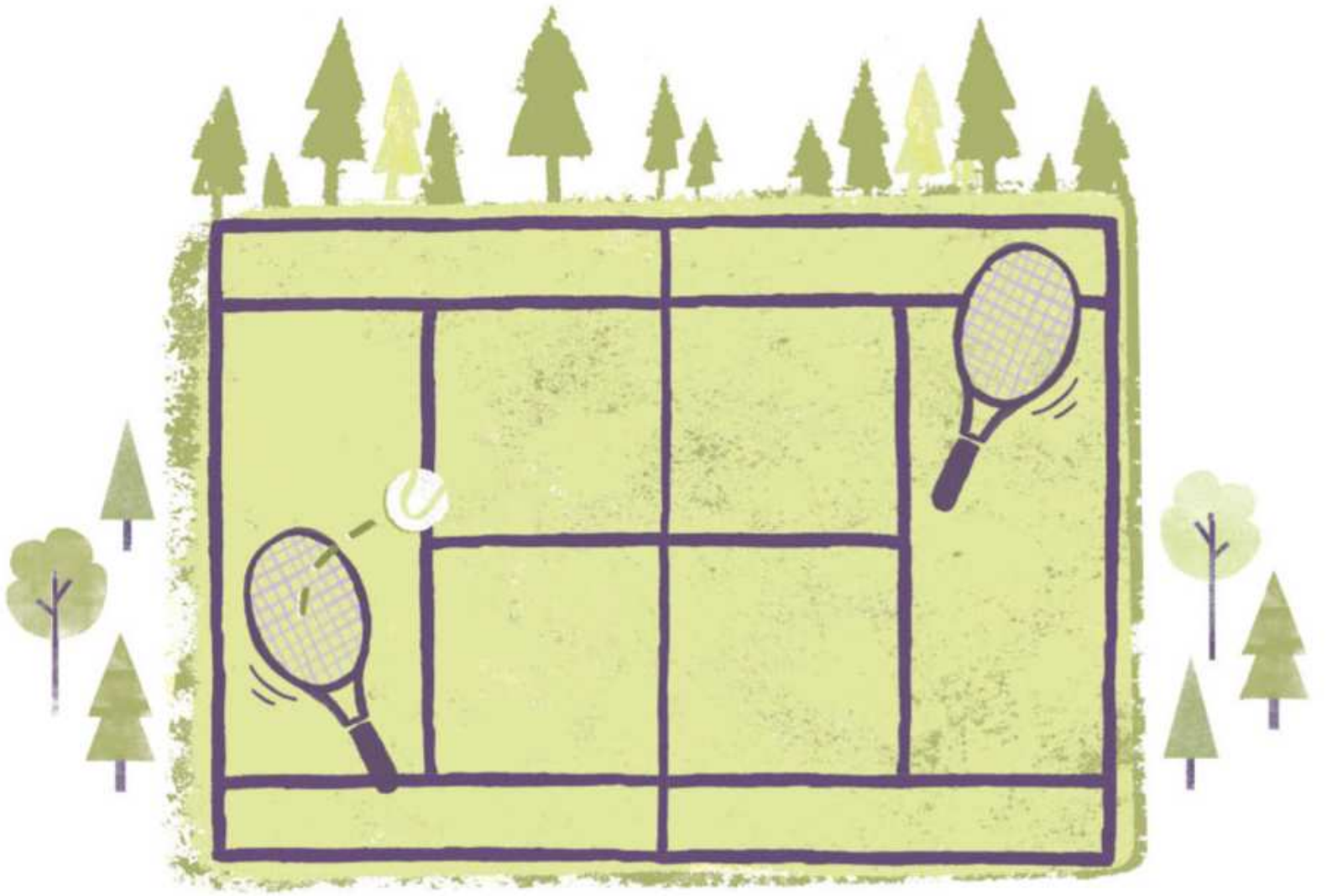

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UNFAO, Global Forest Resources Assessment 2005-2015

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